EPA/ROD/R08-97/145
1997

EPA Superfund
Record of Decision:

CALIFORNIA GULCH
EPA ID: COD980717938
OU 10
LEADVILLE, CO
08/08/1997

<IMG SRC 971450>
<IMG SRC 97145A>

RECORD OF DECISION

OREGON GULCH
OPERABLE UNIT 10
CALIFORNIA GULCH SUPERFUND SITE
LEADVILLE, COLORADO

August 1997

U.S. Environmental Protection Agency
999 18th Street, Suite 500
Denver, Colorado 80202

<IMG SRC 97145B>

RECORD OF DECISION

OREGON GULCH OPERABLE UNIT 10
CALIFORNIA GULCH SUPERFUND SITE
LEADVILLE, COLORADO

The U.S. Environmental Protection Agency (EPA), with the concurrence of the Colorado Department of Public Health and Environment (CDPHE), presents this Record of Decision (ROD) for the Oregon Gulch Operable Unit 10 (OU10) of the California Gulch Superfund Site in Leadville, Colorado. The ROD is based on the Administrative Record for Oregon Gulch OU10, including the Remedial Investigation/Feasibility Study (RI/FS), the Proposed Plan, the public comments received, including those from the potentially responsible parties (PRPs), and EPA responses. The ROD presents a brief summary of the RI/FS, actual and potential risks to human health and the environment, and the Selected Remedy. EPA followed the Comprehensive Environmental Response, Compensation, and Liability Act, as amended, the National Contingency Plan (NCP), and appropriate guidance in preparation of the ROD. The three purposes of the ROD are to:

1. Certify that the remedy selection process was carried out in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. 9601 et seq., as amended by the Superfund Admendments and Reauthorization Act (collectively, CERCLA), and, to the extent practicable, the National Contingency Plan (NCP);

2. Outline the engineering components and remediation requirements of the Selected Remedy; and

3. Provide the public with a consolidated source of information about the history, characteristics, and risk posed by the conditions of Oregon Gulch OU10, as well as a summary of the cleanup alternatives considered, their evaluation, the rationale behind the Selected Remedy, and the agencies' consideration of, and responses to, the comments received.

The ROD is organized into three distinct sections:

1. The Declaration section functions as an abstract for the key information contained in the ROD and is the section of the ROD signed by the EPA Regional Administrator and the CDPHE Director.

2. The Decision Summary section provides an overview of the OU10 characteristics, the alternatives evaluated, and the analysis of those options. The Decision Summary also identifies the Selected Remedy and explains how the remedy fulfills statutory requirements; and

3. The Responsiveness Summary section addresses public comments recieved on the Proposed Plan, the RI/FS, and other information in the Administrative Record.

DECLARATION

SITE NAME AND LOCATION

Oregon Gulch Operable Unit 10
California Gulch Superfund Site
Leadville, Colorado

STATEMENT OF BASIS AND PURPOSE

This decision document presents the Selected Remedy for Oregon Gulch OU10 within the California Gulch Superfund Site in Leadville, Colorado. EPA, with the concurrence of CDPHE, selected the remedy in accordance with CERCLA and the NCP.

This decision is based on the Administrative Record for Oregon Gulch OU10 within the California Gulch Superfund Site. The Administrative Record (on microfilm) and copies of key documents are available for review at the Lake County Public Library, located at 1115 Harrison Avenue in Leadville, Colorado, and at the Colorado Mountain College Library, in Leadville, Colorado. The complete Administrative Record may also be reviewed at the EPA Superfund Record Center, located at 999 18th Street, 5th Floor, North Terrace in Denver, Colorado.

The State of Colorado concurs with the Selected Remedy, as indicated by signature.

ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances at and from Oregon Gulch OU10, if not addressed by implementing the response action selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF THE SELECTED REMEDY

The Selected Remedy is the second response action to be taken at Oregon Gulch OU10 of the California Gulch Superfund Site. The first action taken at Oregon Gulch OU1O was completed in October 1996. This removal action implemented the Action Memorandum (EPA, 1995) for miscellaneous tailings and stream sediment in Oregon Gulch and involved excavation of approximately 3,500 cubic yards of sediment and soil from the channel and floodplain of Oregon Gulch downstream of the Oregon Gulch Tailings Impoundment. The excavated material was then placed on top of the impoundment. Following sediment removal, a channel capable of conveying a 100-year flood event was constructed by mixing limestone in the first foot of subsoil underlying the channel, installing a geotextile, and placing riprap. The area outside the 100-year channel and within the 500-year floodplain was stabilized by placing a 12-inch thick layer of fill in the excavated area, regrading the excavated area, amending the soil, and revegetating. A sedimentation pond was constructed in Oregon Gulch downstream of the toe of the tailings impoundment to reduce sediment load in runoff from the tailings embankment. This removal action is consistent with the Selected Remedy which is described below.

The Selected Remedy for addressing the Oregon Gulch Tailings Impoundment is a Multi-Layer Rock and Soil Cover with a Geosynthetic Barrier as presented in the Final Focused Feasibility Study for Oregon Gulch Operable Unit 10 (SMI/TerraMatrix, 1997) as Alternative 5. The Focused Feasibility Study (FFS) evaluated and screened remedial alternatives retained in the site-wide Screening Feasibility Study (EPA, 1993) for impounded tailings, stream sediment, and fluvial tailings within OU10. The FFS used a comparative analysis to evaluate five alternatives and identify the advantages and disadvantages of each. The Selected Remedy for the tailings impoundment will consist of regrading the impoundment surface to provide positive drainage and flattening the embankment side slopes to 3:1 or less. A geosynthetic barrier will be installed to control infiltration over the entire regraded impoundment (top and side slopes), followed by a geocomposite drainage layer. An 18-inch-thick vegetated soil layer will be placed on the top of the geocomposite drainage layer. On the side slopes, an 18-inch-thick layer of random fill overlain with an erosion-resistant 6-inch-thick gravel layer would be placed over the geocomposite drainage layer. In addition, lined diversion ditches will be constructed to divert potential run-on from the tailings and convey runoff from the covered tailings surface. Adjacent to the impoundment, the diversion ditches will be constructed with a low-permeability lining to eliminate infiltration. A groundwater cut-off trench will also be installed in the

Oregon Gulch paleo-channel upgradient of the impoundment to further prevent shallow groundwater from potentially infiltrating the tailings.

The Selected Remedy includes active managment of the seep currently discharging at the toe of the Oregon Gulch Tailing Impoundment during the interim period from implementation until the seep does not negatively impact surface water quality. Active management of the seep discharge will be performed during non-freezing conditions and will include collection and either pumping or transport of the collected flow to the Yak Tunnel Treatment Plant or other suitable treatment options. Design of the Selected Remedy will include a drain system at the toe of the embankment to allow the seep discharge to flow unrestricted and to be collected in a controlled manner.

The Selected Remedy is protective of human health and the environment through the following:

1. The cover will eliminate airborne transport of tailings particles and limit the potential for contact of precipitation and surface water with tailings material;

2. Ponding of water on the tailings surface will be minimized, reducing infiltration into the impoundment;

3. Infiltration through the tailings will be greatly reduced due to the geosynthetic barrier;.

4. Erosion and transport of tailings will be eliminated by vegetated and gravel surface treatments;

5. Stability of the side slopes will be increased by regrading to flatten existing slopes prior to constructing the soil cover.

STATUTORY DETERMINATIONS

The Selected Remedy is protective of human health and the environment, complies with federal and state requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost effective. Given the type of waste present at this site, this remedy uses permanent solutions (e.g., engineered covers) to the maximum extent practicable and satisfies the preference for remedies that reduce toxicity, mobility, or volume as a principal element. Because this remedy may result in hazardous substances remaining on site above health-based levels, a review will be conducted within five years after commencement of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment. This remedy is acceptable to both the State of Colorado and the community of Leadville.

<IMG SRC 97145C>

DECISION SUMMARY

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LIST OF ACRONYMS AND ABBREVIATIONS

AMSL	Above Mean Sea Level
AOC	Administrative Order on Consent
AWQC	Ambient Water Quality Criteria
BARA	Baseline Aquatic Ecological Risk Assessment
CD	Consent Decree
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COCs	Contaminants of Concern
CPT	Cone Penetrometer Test
CZL	Colorado Zinc-Lead
EE/CA	Engineering Evaluation/Cost Analysis
EPA	Environmental Protection Agency
ERA	Ecological Risk Assessment
FFS	Focused Feasibility Study
HI	Hazard Index
HQ	Hazard Quotient
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NRHP	National Register of Historic Places
OGDD	Oregon Gulch Drainage Ditch
OGPD	Oregon Gulch Pond
OGS	Oregon Gulch Seep
OGUP	Oregon Gulch Upgradient
OU	Operable Unit
PERAOG	Preliminary Ecological Risk Assessment for Oregon Gulch
PRPs	Potentially Responsible Parties
RI/FS	Remedial Investigation/Feasibility Study
RME	Reasonable Maximum Exposure
ROD	Record of Decision
RUSLE	Revised Universal Soils Loss Equation
SFS	Screening Feasibility Study
SPT	Standard Penetration Test
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
UAO	Unilateral Administrative Order
WAMP	Work Area Management Plan

1.0 SITE NAME, LOCATION, AND DESCRIPTION

Oregon Gulch Operable Unit 10
California Gulch Superfund Site
Leadville, Colorado

The California Gulch Superfund Site is located in Lake County, Colorado, in the upper Arkansas River basin, approximately 100 miles southwest of Denver (see Figure 1). The study area at the Site encompasses approximately 16.5 square miles and includes the towns of Leadville and Stringtown, a portion of the Leadville Historic Mining District, and the portion of the Arkansas River from its confluence with California Gulch downstream to the Lake Fork Creek confluence. Oregon Gulch is an ephemeral tributary to California Gulch that flows only during the spring runoff event and during summer storms. The Oregon Gulch watershed drains approximately 185 acres including the 15.8-acre area of OU10. The California Gulch Superfund Site has been organized into 12 operable units (OUs). Figure 2 shows the Site study area boundaries and the location of OU10 within the California Gulch Superfund Site.

OU10 is defined as the 500-year floodplain of Oregon Gulch from its headwaters to its confluence with California Gulch (USDC, 1994). Sources of metal loading within OU10 include the Oregon Gulch Tailings Impoundment and miscellaneous tailings and stream sediment contained within the 500-year floodplain of lower Oregon Gulch. Lower Oregon Gulch is defined as the portion of the gulch downstream of the tailings impoundment.

The Oregon Gulch Tailings Impoundment and the 500-year floodplain of Oregon Gulch comprise approximately 14.2 acres and 1.6 acres, respectively, of the area of OU10. Oregon Gulch is a small V-shaped valley with surface water flowing in a northwesterly direction. The gulch extends approximately one mile from its headwaters, at an elevation of approximately 10,400 feet above mean sea level (AMSL), to the confluence with California Gulch, at an elevation of approximately 10,025 feet AMSL. The tailings impoundment is located approximately 1/2 mile upstream of the confluence of Oregon and California gulches and contains approximately 485,000 cubic yards of tailings. Based on analysis of tailings samples collected from the impoundment, the tailings represent a source of inorganic metals including arsenic, cadmium, copper, lead, silver, and zinc. A perennial seep discharges at the toe of the tailings impoundment and represents a source of acidic water and metals loading to surface water and groundwater in lower Oregon Gulch (SMI/TerraMatrix, 1997).

Lake County is relatively small (380 square miles) and is predominately rural, with a 1990 population of 6,007 (U.S. Department of Commerce, 1990). About half of this population resides within the City of Leadville. The population of Lake County has fluctuated with the mining industry. The population increased to about 9,000 between 1960 and 1981 and then declined throughout the 1980's. About two-thirds of the land in Lake County is federally owned and is either part of San Isabel National Forest or managed by the Bureau of Land Management.

Land surrounding and within California Gulch is predominately dedicated to mining, commercial, and residential uses (SMI/TerraMatrix, 1997).

Land within OU10 is privately owned by either the Res-Asarco Joint Venture or Resurrection Mining Company, except for County Road 6, which is owned by Lake County and two small parcels of federally owned land managed by the Bureau of Land Management. County Road 6 crosses Oregon Gulch approximately 90 feet upstream of its confluence with California Gulch. A corrugated metal culvert conveys surface flow under County Road 6. A dirt road extends from County Road 6 near the confluence of Oregon and California Gulches to the tailings impoundment. The dirt road was extended past the impoundment and to the southwest to re-connect with County Road 6 during construction in 1995. No other improvements or structures exist in Oregon Gulch (SMI/TerraMatrix, 1997).

The climate of Lake County is dry, but otherwise typical of most alpine regions in the southern Rocky Mountains. The average annual maximum temperature in the Leadville area is 50.5 degrees Fahrenheit and the average annual minimum temperature is 21.9 degrees Fahrenheit, with an annual mean temperature of 37.3 degrees Fahrenheit. The south-central portion of the county, at an elevation near 9,000 feet AMSL, receives about 10 inches of precipitation annually. Wind is predominantly from the northwest, with speeds typically from 0 to 30 miles per hour (mph) (WCC, 1994). Populated areas of Leadville are predominantly upwind of OU10 (SMI/TerraMatrix, 1997).

2.0 OPERABLE UNIT HISTORY AND ENFORCEMENT ACTIVITIES

The California Gulch Superfund Site is located in the highly, mineralized Colorado Mineral Belt of the Rocky Mountains. Mining, mineral processing, and smelting activities have produced gold, silver, lead, and zinc for more than 130 years in the Leadville area. Mining and its related industries continue to be a source of income for both Leadville and Lake County. The Leadville Historic Mining District includes an extensive network of underground mine workings in a mineralized area of approximately 8 square miles located around Breece Hill. Mining in the District began in 1860, when placer gold was discovered in California Gulch. As the placer deposits were exhausted, underground workings became the principle method for removing gold, silver, lead, and zinc ore. As these mines were developed, waste rock was excavated along with the ore and placed near the mine entrances. Ore was crushed and separated into metallic concentrates at mills, with mill tailings generally slurried into tailings impoundments.

The Oregon Gulch Tailings Impoundment received tailings from the Resurrection-Asarco mill in California Gulch from approximately 1942 through 1957 (Foothill Engineering Consultants [FEC], 1995). Removal action activities, performed during September and October 1995, included the relocation of 28,000 cubic yards of tailings and underlying soil from the Colorado Zinc-Lead (CZL) Tailings Impoundment to the Oregon Gulch Tailings Impoundment (SMI/TerraMatrix, 1995a). An additional 550 cubic yards of sediment excavated from the culvert and embankment in California Gulch, on property owned by Dorothy Hayes, within OU8 were deposited on top of the Oregon Gulch Tailings Impoundment in September 1996 (SMI/TerraMatrix, 1997).

The California Gulch Site was placed on the National Priorities List (NPL) in 1983, under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. The Site was placed on the NPL because of concerns about the impact of mine drainage on surface waters in the California Gulch and the impact of heavy metals loading in the Arkansas River (EPA, 1997). Several subsequent investigations have been conducted within the California Gulch Superfund Site that have addressed the Oregon Gulch Tailings Impoundment (OU10).

The investigation conducted by Dames & Moore (D&M, 1986) was performed to assess the slope stability of existing tailings impoundments in California Gulch and Oregon Gulch. The investigation also included development of conceptual remediation plans for the impoundments, surface water drainage and runoff controls, and addressed erosional concerns related to the tailings impoundments. With respect to the Oregon Gulch Tailings Impoundment, the investigation consisted of performing a site reconnaissance, and soil sampling to determine the engineering characteristics of the tailings and foundation soils (SMI/TerraMatrix, 1997).

Water, Waste and Land, Inc. (WWL) conducted a hydrologic investigation of the California Gulch drainage for Resurrection Mining Company in 1989 (WWL, 1990). The study included surface water, groundwater, and sediment sampling, laboratory analysis of samples, and an inventory of mine wastes. The primary objectives of the investigation were to characterize the surface water and groundwater quality and flow patterns, and to identify sources of metal loading in California Gulch. Surface water was sampled at 49 locations and sediment was sampled at 50 locations in June 1989. Thirty-four locations were sampled for surface water in the fall of 1989. The sample locations included Califomia Gulch and tributary drainages, including Oregon Gulch.

In September 1990, EPA and the potentially responsible parties (PRPs) entered into an Administrative Order on Consent (AOC) for the performance of soils sampling and air monitoring. EPA issued a Unilateral Administrative Order (UAO) which required Resurrection to conduct and complete the final Soils Investigation Work Plan. Field work was completed in 1992 (EPA, 1997).

A surface water remedial investigation (Surface Water RI) of the California Gulch Site was conducted in 1991 and 1992. The final Surface Water RI report was issued in 1996 by Golder and Associates describing the results of the surface water investigation (Golder, 1996a). The study included surface water and sediment sampling in the Arkansas River anct its tributaries, including California Gulch. Oregon Gulch was sampled at one site just upstream of its confluence with California Gulch. California Gulch was sampled upstream and downstream of its confluence with Oregon Gulch.

A groundwater remedial investigation (Hydrogeologic RI) at the California Gulch Site was conducted from the fall of 1991 through the winter of 1992. The study included installation of monitoring wells and piezometers, water level measurements, and groundwater sampling and analysis. The final Hydrogeologic RI Report describing the results of the investigation was issued by Golder and Associates in 1996 (Golder, 1996b). Objectives of the study were to investigate groundwater quality and flow directions, evaluate potential impacts to surface water receptors, and to characterize background groundwater quality. Oregon Gulch groundwater was sampled at six monitoring wells. Additional piezometers and monitoring wells in the vicinity of the confluence of Oregon Gulch and California Gulch were utilized to evaluate the impacts of Oregon Gulch surface water and groundwater on California Gulch groundwater.

The Tailings RI (WCC, 1994) performed in the fall of 1991 was a comprehensive investigation encompassing five major tailings impoundments and seven fluvial tailings deposits at the California Gulch Site. The field programs related to the Oregon Gulch Tailings Impoundment consisted of the following activities: (1) collection of surface tailings composite samples for geochemical analysis; (2) drilling of 11 borings in or near the impoundment for geochemical and geotechnical testing of subsurface material properties; (3) completion of monitoring wells in eight of the borings for groundwater level measurements, in-situ permeability tests, and groundwater sampling; (4) collection of surface water and groundwater samples to characterize water quality upgradient and downgradient of the impoundment; and (5) collection of water samples from wells completed within the impoundment to characterize the quality of the tailings pore water (SMI/TerraMatrix, 1997).

In 1993, the EPA conducted a Screening Feasibility Study (SFS) (EPA, 1993) to initiate the overall Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) FS process at the California Gulch Site. The purpose of the SFS was to develop general response actions and identify an appropriate range of alternatives applicable to the various contaminant sources to be considered during feasibility studies for the California Gulch Site. Remedial alternatives retained in the SFS for impounded tailings, stream sediments, and fluvial tailings in OU10 were further evaluated and screened during the FFS (SMI/TerraMatrix, 1997).

Resurrection entered into a Consent Decree (CD) (USDC, 1994) with the United States, the State of Colorado (State), and other potentially responsible parties (PRPs) at the California Gulch Site on May 4, 1994. In the CD, Resurrection agreed to perform certain remediation work in three operable units (OU4,OU8, and OU10). The Work Area Management Plan (WAMP), included as Appendix D to the CD (USDC, 1994), defines the scope of work to be performed by Resurrection.

As a part of the scope, the cultural resources of OU1O were surveyed by Foothills Engineering Consultants (FEC) on June 23, 1994 and by P-III Associates, Inc. (P-III) on June 28, 1995. FEC surveyed the area of the tailings impoundment and the channel in lower Oregon Gulch. P-III surveyed an additional 30 acres of Oregon Gulch that would potentially be disturbed during remedial activities, including the proposed borrow area and access road corridors. The areas surveyed are discussed in greater detail in Final Cultural Resources Survey of Oregon Gulch Operable Unit 10, California Gulch Superfund Site, Lake County, Colorado (FEC, 1995) and in Cultural Resource Inventory of Access Roads and a Borrow Location in the Oregon Gulch Area, Operable Unit 10, California Gulch, CERCLA Site, Lake County, Colorado (P-III, 1995).

An Engineering Evaluation/Cost Analysis (EE/CA) (SMI/TerraMatrix, 1995b) was prepared to evaluate and identify a removal action for miscellaneous tailings and stream sediment contained within the 500-year floodplain of Oregon Gulch. An Action Memorandum (EPA, 1995) was issued on August 4, 1995 by the EPA to select the removal action. The Action Memorandum selected the following alternatives for the removal action: (1) Channel Alternative - 10-year channel, (2) Stabilization Alternative - Excavation and Reconstruction, and (3) Cultural Resource Alternative - Reconstruct Existing Channel. The Final Removal Action Design Report (SMI/TerraMatrix, 1995c) was submined to the EPA on August 28, 1995, and the Removal Action Work Plan (SMI/TerraMatrix, 1995d), which provided an implementation plan, was submitted on September 8, 1995. Implementation of the removal action was initiated during the fall of 1995 and was completed in the fall of 1996.

The selected removal action for the miscellaneous tailings and stream sediment in Oregon Gulch was an interim response. It is consistent with the performance of the final remedial action selected for OU10.

In 1994 Resurrection initiated a geotechnical investigation (SMI/TerraMatrix, 1995e) of the Oregon Gulch Tailings Impoundment. The goals of the investigation were: (1) to better define the stratigraphic profile of the impoundment, (2) to determine the position of the phreatic surface within the impoundment, and (3) to refine the existing characterization of material properties of the tailings, embankment, and foundation soils. The field program included drilling seven borings within the impoundment, collection of soil samples for geotechnical analysis, and installation of piezometers.

Resurrection conducted the FFS for OU10 in order to expedite remediation. The FFS followed the general FS process (EPA, 1988), but relevant remedial alternatives were screened to produce a set of alternatives that were then analyzed in detail. A Work Plan for the Focused Feasibility Study of Oregon Gulch Operable Unit 10 (Work Plan) (SMI/TerraMatrix, Inc., 1996b) was submitted to EPA on January 23, 1996. EPA approval of the Work Plan was received by Resurrection on May 16, 1996. The Work Plan described the tasks to be performed by Resurrection during the FFS.

In December of 1996, Resurrection submitted the Draft Focused Feasibility Study for Oregon Gulch Operable Unit 10 (SMI/TerraMatrix 1996a), according to the terms of the Consent Decree. The FFS provided a detailed analysis of the five retained remediation alternatives from the SFS as applied to the Oregon Gulch Tailings Impoundment and alternatives from the SFS for stream sediment.

A Proposed Plan describing the EPAs preferred alternative was issued on March 19, 1997. The preferred alternative was Alternative 5, Multi-Layer Rock and Soil Cover with a Geosynthetic Barrier. The Final Focused Feasibility Study for Oregon Gulch OU10 (SMI/TerraMatrix, 1997) was issued in June 1997.

3.0 HIGHLIGHTS OF COMMUNITY PARTICIPATION

Public participation is required by CERCLA Sections 113 and 117. These sections require that before adoption of any plan for remedial action to be undertaken by EPA, the State, or an individual (PRP), the lead agency shall:

1. Publish a notice and brief analysis of the Proposed Plan and make such plan available to the public; and

2. Provide a reasonable opportunity for submission of written and oral comments and an opportunity for a public meeting at or near the site regarding the Proposed Plan and any proposed findings relating to cleanup standards. The lead agency shall keep a transcript of the meeting and make such transcript available to the public. The notice and analysis published under item #1 above shall include sufficient information to provide a reasonable explanation of the Proposed Plan and alternative proposals considered.

Additionally, notice of the final remedial action plan set forth in the ROD must be published and the plan must be made available to the public before commencing any remedial action. Such a final plan must be accompanied by a discussion of any significant changes to the preferred remedy presented in the Proposed Plan along with the reasons for the changes. A response (Responsiveness Summary) to each of the significant comments, criticisms, and new data submitted in written or oral presentations during the public comment period must be included with the ROD.

EPA has conducted the required community participation activities through the presentation of the RI/FS and the Proposed Plan, a 30-day public comment period, a formal public hearing, and the presentation of the Selected Remedy in this ROD. No comments were received during the public comment period.

The Proposed Plan for Oregon Gulch OU10 was released for public comment on March 19,

1997. The RI/FS and the Proposed Plan were made available to the public in the Administrative Record located at the EPA Superfund Records Center in Denver and the Lake County Public Library in Leadville. A formal public comment period was designated from March 19, through April 18, 1997.

On March 19, 1997, the EPA hosted a public meeting to present the Proposed Plan for Oregon Gulch OU10 of the California Gulch Superfund Site. The meeting was held at 7:00 p.m. in the Mining Hall of Fame in Leadville, Colorado. Representatives from the Resurrection Mining Company presented the Proposed Plan. Five alternatives were discussed: No Action, Simple Vegetated Cover, Clay Layer with a Vegetated Cover, Multi-Layer Soil Cover with a Geosynthetic Barrier and Multi-Layer Rock and Soil Cover with a Geosynthetic Barrier. The Multi-Layer Rock and Soil Cover with a Geosynthetic Barrier was presented as EPA's and Resurrection's preferred alternative. A portion of the hearing was dedicated to accepting formal oral comments from the public. Community acceptance of the Selected Remedy is discussed in Section 8.0, Summary of Comparative Analysis of Alternatives, of this Decision Summary.

4.0 SCOPE AND ROLE OF OPERABLE UNIT

The California Gulch Superfund Site covers a wide area (Figure 2). EPA has established the following OUs for the cleanup of geographically-based areas within the Site. The OUs are designated as:

OU1	Yak Tunnel/Water Treatment Plan
OU2	Malta Gulch Fluvial Tailings/Leadville Corporation Mill/Malta Gulch Tailings Impoundment
OU3	D&RGW Slag Piles/Railroad Easement/Railroad Yard and Stockpiled Fine Slag
OU4	Upper California Gulch
OU5	ASARCO Smelter/Slag/Mill Sites
OU6	Starr Ditch/Penrose Dump/Stray Horse Gulch/Evans Gulch
OU7	Apache Tailings Impoundment
OU8	Lower California Gulch
OU9	Residential Populated Areas
OU10	Oregon Gulch
OU11	Arkansas River Valley Floodplain
OU12	Site Water Quality

The purpose of the Oregon Gulch OU10 RI/FS was to gather sufficient information to support an informed risk management decision on which remedies are the most appropriate for the sources within OU1O (namely the Oregon Gulch Tailings Impoundment and the stream sediments). The RI/FS was performed in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) Part 300, and CERCLA Section 104, 42 U.S.C. º 9604.

The objectives of the RI/FS were to:

- Characterize the physical nature of the tailings and stream sediments, and to evaluate the potential impacts of tailings and stream sediments to the surface water and groundwater.
- Define the potential pathways along which metals can migrate, as well as the physical processes and, to the extent necessary, the chemical processes that control these pathways;
- Determine risk assessment information including potential receptors, exposure patterns, and food chain relationships;
- Develop, screen, and evaluate remedial alternatives and predict the consequences of each remedy;
- Analyze each of the FS alternatives against the NCP (40 C.F.R. 300.430) criteria; and
- Compare the relative performance among each alternative with respect to the evaluation criteria.

Based on the findings of previous investigations and the results of the Tailings RI (WCC, 1994), the contamination at the Oregon Gulch Tailings Impoundment has been adequately delineated to evaluate alternatives in the RI/FS.

This ROD was prepared according to EPA guidance (EPA, 1989). The remedy outlined in this ROD is intended to be the final remedial action for OU10. The primary objectives of the remedy presented in this ROD are:

- Control airborne transport of tailings particles;
- Control erosion of tailings materials and deposition into local water courses;
- Control leaching and migration of metals from tailings into surface water; and
- Control leaching and migration of metals from tailings into groundwater.

Remedial actions undertaken within OU10 are intended to be consistent with the remedial action objectives and goals identified for the entire California Gulch Superfund Site and other OU investigations.

5.0 SUMMARY OF SITE CHARACTERISTICS

5.1 PHYSICAL CHARACTERISTICS

Oregon Gulch is an ephemeral tributary to California Gulch that flows only during the spring runoff event and during summer storms. The Oregon Gulch watershed drains approximately 185 acres, including the 15.8 acre area of OU10. The Oregon Gulch Tailing Impoundment and the 500-year floodplain of Oregon Gulch comprise approximately 14.2 acres and 1.6 acres, respectively, of the area of OU10. The Oregon Gulch Tailings Impoundment is located approximately 1/2 mile upstream of the confluence of Oregon and California gulches and contains approximately 485,000 cubic yards of material (SMI/TerraMatrix, 1997). The maximum depth of the impoundment is approximately 75 feet. Figure 3 shows the location of the impoundment and the surrounding area.

Surface water flow upgradient of the impoundment is diverted into one of three diversion ditches (see Figure 3). The surface of the tailings impoundment slopes at approximately 2 percent from the impoundment margins toward the interior of the impoundment where precipitation and runoff water form a shallow pond estimated to be 0.5 to 1 foot deep. The pond exists year-round, but fluctuates in size with snowmelt and precipitation events. The impoundment surface is covered by sand-sized and finer tailings that are generally oxidized and are predominately orange to red in color. A significant amount of un-oxidized pyritic, fine- to medium-grained sized tailings are present on the impoundment surface. The side slopes of the embankment are generally comprised of course-grained tailings sand. Slopes vary from 2:1 (horizontal:vertical) to 1.5:1. Minor surface erosion, caused by snowmelt and precipitation events, has transported materials down the embankment, resulting in the formation of small gullies along the embankment face (SMI/TerraMatrix, 1997).

5.2 GEOTECHNICAL EVALUATION

Three separate studies examined the physical and geotechnical properties of tie Oregon Gulch Tailings Impoundment: Report of Stability and Reclamation Evaluation, Abandoned Tailings Ponds, Leadville Unit, Leadville, Colorado, for ASARCO Incorporated (Dames & Moore [D&M], 1986); Final Tailings Disposal Area Remedial Investigation Report, California Gulch Site, Leadville, Colorado, (Tailings RI; Woodward Clyde Consultants (WCC], 1994); and Geotechnical Investigation Report, Oregon Gulch Tailings Impoundment Operable Unit 10 (Geotechnical Investigation Report; Shepherd Miller, Inc. (SMI/TerraMatrix, 1995e). Data and information resulting from these studies provide a comprehensive characterization of the physical and geotechnical properties of the Oregon Gulch Tailings Impoundment.

Numerous laboratory geotechnical tests were performed on tailings samples collected from the impoundment including: grain size analyses, hydrometer tests, Atterberg limits, moisture content, specific gravity, dry density, direct shear tests, consolidation tests, triaxial tests, and permeability tests. The results of these tests are summarized in Appendix D of the FFS

(SMI/TerraMatrix, 1997).

Generally, the tailings impoundment is comprised of a combination of: 1) cohesionless granular fine-grained sand tailings exhibiting a wide range of relative densities and moisture contents, and 2) soft to moderately firm, weakly cohesive silt and clay (slime) tailings. Native alluvium underlying the Oregon Gulch Tailings Impoundment consists of a mixture of sand, silt, and clay in varying proportions, along with lesser amounts of gravel. The density of the tailings sand comprising the embankment ranges from loose to medium dense based on Standard Penetration Tests (SPT) performed during drilling and the results of the Cone Penetrometer Test (CPT) investigation (SMI/TerraMatrix, 1995e). This range of density is normal for hydraulically deposited sands.

5.3 NATURE AND EXTENT OF CONTAMINATION

Media evaluated include surface and subsurface soil, tailings, surface water, groundwater and stream sediments within and downgradient of OU10. The following sections summarize the nature and extent of contamination for each of these media.

5.3.1 SURFACE AND SUBSURFACE SOIL AND TAILINGS

As part of the tailings RI, three surface tailings composite samples (0 to 0.15 feet deep) were collected from the impoundment. Each composite sample consisted of 10 individual subsamples collected from: 1) the embankment face, 2) the crest of the embankment, and 3) the interior surface of the impoundment. Subsurface tailings and alluvial foundation samples were collected from borings OG1B4, OG1B5, OG1B6, OB1B7, OB1B9, and OG1B10, drilled during the Tailings RI. The locations of the borings are shown in Figure 4.

Tailings and foundation soil samples collected for Tailings RI were analyzed for arsenic, cadmium, lead, and zine. Selected samples were also analyzed for the following additional metals: antimony, barium, beryllium, chromium, copper, manganese, mercury, nickel, silver, and thallium. A summary of arsenic, cadmium, lead, and zinc concentrations of tailings surface composite samples, tailings subsurface samples, and foundation soil samples is presented in Table 1. Surface tailings median concentrations of metals were as follows: arsenic - 747 milligrams per kilogram (mg/kg), cadmium - 9.5 mg/kg, lead - 2,170 mg/kg, and zinc - 1,280 mg/kg, respectively.

Median constituent concentrations in subsurface tailings samples were: arsenic - 439.5 mg/kg, cadmium - 47.4 mg/kg, lead - 3,475 mg/kg, and zinc - 8,720 mg/kg (Table 1). The highest concentrations of these metals were: arsenic - 1,430 mg/kg (OG1B6), cadmium - 196 mg/kg (OG1B9), lead - 13,800 mg/kg (OB1B10), and zinc - 29,300 mg/kg (OG1B9). Concentrations of lead and zinc are relatively consistent throughout the tailings profile, while arsenic and cadmium concentrations tend to decrease with depth.

Metal concentrations in foundation soils were significantly less than concentrations of tailings samples collected from the impoundment. Median concentrations of metals in the foundation soils were: arsenic - 12.8 mg/kg, cadmium - 1.2 mg/kg, lead - 77 mg/kg, and zinc - 185.5 mg/kg (SMI/TerraMatrix, 1997).

5.3.2 SURFACE WATER

The Oregon Gulch channel downstream of the impoundment is approximately 2,700 feet long, and drains to the northwest into California Gulch (Figure 3). A perennial seep emerges near the toe of the tailings impoundment and generally infiltrates into the Oregon Gulch alluvium after flowing a short distance downstream of the impoundment. A berm along the tailings embankment crest prevents surface water from overflowing the impoundment. A perennial surface water pond exists near the southeastern edge of the impoundment. The surface area of the pond is typically about one acre, but fluctuates seasonally depending on climatic conditions.

Surface water quality in Oregon Gulch is characterized by low pH and elevated metal concentrations. The Oregon Gulch Tailings Impoundment is the primary source of acidic water and metals loading in Oregon Gulch. Concentrations of metals in surface water upstream of the impoundment are lower than in surface water in Oregon Gulch downstream of the impoundment. The seep discharging near the toe of the Oregon Gulch Tailings Impoundment is acidic and contains elevated metal concentrations that represent a source of metal loading to Oregon Gulch. Potential contaminants of concern (COCs) in Oregon Gulch surface waters are total suspended solids (TSS), metals (arsenic, cadmium, copper, lead and zinc), sulfate, and low pH.

Surface water quality sampling has been conducted at six locations in Oregon Gulch between 1989 and June 1996. The locations, shown on Figure 5, are: 1) ponded water on the tailings impoundment (OGPD), 2) the tailings impoundment seep (OGS), 3) the sediment pond outlet (OG-2 - post fall 1995), 4) the south diversion ditch around the southwest perimeter of the impoundment at the confluence with Oregon Gulch (OGDD), 5) Oregon Gulch upgradient of the tailings impoundment (OGUP), and 6) Oregon Gulch just upstream of the confluence with California Gulch (OG-1) (SMI/TerraMatrix, 1997).

Tailings Ponded Water Quality The water ponded on top of the Oregon Gulch Tailinngs Impoundment was sampled during four events: June 1989, September 1991, June 1995, and June 1996. Analytical results are included in Table 2. The source of the ponded water is precipitation and runoff from the surface of the tailings. The water quality of the pond is affected by dissolution of metals from the tailings. Concentrations of arsenic, cadmium, copper and lead were elevated as compared to concentrations of surface water in Oregon Gulch at OG-1. Total constituent concentrations in ponded water were similar to the dissolved concentrations. Dissolved and total concentrations of arsenic and copper detected in samples of the ponded water are the highest concentrations observed in any surface water samples collected in OU10. Seasonal variation in the concentrations can be attributed to dilution by snowmelt in spring and early summer resulting in lower concentrations and evaporation of ponded water causing higher concentrations in the fall (SMI/TerraMatrix, 1997).

Tailings Seep Water Quality The seep emerging from the toe of the Oregon Gulch Tailings Impoundment has been sampled on thirteen occasions from 1989 through June 1996. Table 3 presents the analytical results and mass loading for selected constituents from the seep samples. Field pH ranged between 2.64 andd 3.21. For all sampling events except the June 1, 1995 event, concentrations of zinc and sulfate vary within a narrow range, while concentrations of other constituents vary approximately one order of magnitude. The June 1, 1995 sample included discharge from an abandoned decant line that draining ponded water from the top of the tailings impoundment. Seep samples collected on that date had lower concentrations of sulfate, zinc, total dissolved solids (TDS), and TSS due to dilution by the decant flows.

Dissolved zinc concentrations at the seep typically comprise 90 percent of the total zinc concentrations. Dissolved concentrations of arsenic, cadmium, and copper were also similar to the total concentrations. However, total concentrations of lead were typically greater than the dissolved concentrations of lead by at least a factor of 2.

Comparison of chemical analyses of the seep with flows at the mouth of Oregon Gulch indicates that the seep concentrations are higher than surface flow concentrations for each analyte of concern except cadmium for dates when samples were collected at both sites, but the pH values are slightly lower at the mouth of Oregon Gulch. Ranges of the (SMI/TerraMatrix, 1997) COC concentrations vary less for the seep than COC concentration ranges in Oregon Gulch. Comparisons of chemical analyses of the seep with the ponded water on top of the impoundment indicate that the seep has higher concentrations of cadmium, zinc, and sulfate, whereas pH values are lower in the pond (SMI/TerraMatrix, 1997).

South Diversion Ditch Water Quality The south diversion ditch was sampled at its confluence with Oregon Gulch on June 1, 1995, and May 8 and May 17, 1996. Table 4 presents the COC concentrations and mass loadings. Dissolved metals concentrations in surface water samples from the south diversion ditch were significantly lower in comparison with metal concentrations of the tailings ponded water, tailings seep, and Oregon Gulch surface water at OG-1. Sulfate concentrations average 60 mg/L and the field pH average 3.81. The TDS concentration average was 106.7 mg/L, while the average TSS concentration was 694 mg/L. Total concentrations of arsenic, lead, and copper were significantly higher than the dissolved concentrations. Comparison of dissolved to total concentrations indicates that all of the cadmium was in the dissolved form, dissolved arsenic was 3.8 percent of the total arsenic, dissolved lead was 2 percent of the total lead, dissolved copper was 30 percent of the total copper, and dissolved zinc was 68 percent of the total zinc (SMI/TerraMatrix, 1997).

Upgradient Water Quality Surface water in Oregon Gulch was sampled upgradient of the tailings impoundment on May 8, 1996. The sample was collected in the south diversion ditch just downstream of the confluence of the east diversion ditch with the Oregon Gulch stream channel (Figure 5, OGUP). Metals concentrations in the upgradient sample were above detection but were significantly lower in comparison with metal concentrations in samples from the south diversion ditch. Dissolved arsenic was <0.001 mg/L, and total arsenic was 0.015 mg/L. Dissolved cadmium was 0.003 mg/L, and total cadmium was 0.005 mg/L. Dissolved copper was 0.003 mg/L and total copper was 0.02 mg/L. Dissolved lead was 0.002 mg/L and total lead was 0.201 mg/L. Dissolved zinc was 0.4 mg/L and total zinc was 0.78 mg/L. Field pH was 5.37, and field conductivity was 50 Imhos/cm. Sulfate concentration was 10 mg/L. The TDS concentration was below the detection level of 40 mg/L, while the TSS concentration was 316 mg/L. Total concentrations of COCs were significantly higher than dissolved COC concentrations.

Oregon Gulch Water Quality Surface water in Oregon Gulch was sampled at the confluence with California Gulch (OG-1, Figure 5) on 21 occasions between 1991 and June 1996. COC concentrations and mass loadings are presented in Table 5. Over the seven year sampling period, the pH of Oregon Gulch surface flows has ranged between 2.20 and 3.49, and TDS concentrations have ranged from 740 to 37,900 mg/L. For most of the sampling events, dissolved concentrations of cadmium, copper, and zinc comprise the majority of each metal present, whereas total concentrations of lead and arsenic are significantly higher than dissolved concentrations.

The analytical results show general patterns of lower constituent concentrations during high flow events, presumably due to dilution by runoff. Metals concentrations generally increase with increased flowrates, then diminish prior to peak flows. Evaluation of the sources of flow within Oregon Gulch indicate that the south diversion ditch contributes a majority of the flow measured in Oregon Gulch at OG-1 during the spring runoff event. The relatively higher flows and lower constituent concentrations of the south diversion ditch tend to dilute the concentrations at OG-1 (SMI/TerraMatrix, 1997).

5.3.3 GROUNDWATER

Groundwater in Oregon Gulch is contained in consolidated bedrock, unconsolidated glacial till and outwash sediments, alluvium, and as pore water within the Oregon Gulch Tailings Impoundment. Three aquifer systems have been identified in Oregon Gulch. The deepest is the bedrock aquifer. Overlying the bedrock in unconsolidated alluvial and glacial sediments is an intermediate alluvial aquifer. A perched aquifer exists downgradient of the tailings impoundment in the shallow alluvial sediments of Oregon Gulch. A perched saturated zone has also been identified within the Oregon Gulch Tailings Impoundment.

Monitoring wells and piezometers have been completed within the tailings impoundment and within alluvium in surrounding areas to better characterize the hydrogeologic conditions in Oregon Gulch. Figure 5 shows the locations of the monitoring wells and the piezometers. The EPA installed a monitoring well (NW-4) in Oregon Gulch 500 feet downstream of the toe of the tailings embankment. As part of the Tailings RI, eight monitoring wells were installed in the vicinity of OU10: one upstream of the Oregon Gulch Tailings Impoundment, four within the tailings impoundment, and three downstream of the impoundment in Oregon Gulch. A monitoring well (OG1TMW9, Figure 4) was installed in Oregon Gulch downstream of the impoundment in 1994 (SMI/TerraMatrix, 1994). Additional hydrologic data were gathered from borings and CPTs during a geotechnical investigation of the tailings impoundment (SMI/TerraMatrix, 1995e). During this investigation, one impoundment boring, OG1TP-1, was completed as a piezometer. Groundwater levels have been measured in the intermediate alluvial aquifer monitoring wells, the shallow perched aquifer in Oregon Gulch, and within the tailings impoundment (SMI/TerraMatrix, 1997).

Groundwater piezometric contour maps and cross-sections have been prepared for the intermediate alluvial and shallow perched aquifers in the vicinity of Oregon Gulch. Groundwater elevations in monitoring wells OG1TMW1 and OG1TMW9 (Figure 5), completed in the intermediate alluvial aquifer, indicate that approximately 100 feet of unsaturated alluvium exists beneath the tailings impoundment. Water elevations in the intermediate alluvial aquifer (OG1TMW1, OG1TMW9, PZ6, AP1TMW7, and NW16) on Figure 5 indicate that the hydraulic gradient is approximately 6 percent to the west. The perched saturated zone within the tailings extends from the seep at the northwest embankment to within the interior of the impoundment. Water within the impoundment flows toward the seep at an average gradient of approximately 8 percent. The southwest embankment and a majority of the northern embankment appear to be unsaturated. The maximum saturated tailings thickness of approximately 35 feet occurs within the impoundment approximately 200 feet southeast of the embankment crest.

Surface water quality criteria have also been utilized to identify COCs for OU10 groundwater due to the interaction between shallow groundwater and surface water. The Preliminary Ecological Risk Assessment for Oregon Gulch (PERAOG) (Weston, 1995a) determined surface water COCs to be cadmium, copper, and zinc based on potential acute exposure to aquatic life. Arsenic, cadmium, copper, lead, zinc, and sulfate were also listed based on chronic exposure to aquatic life. Arsenic, cadmium, copper, lead, zinc and sulfate were identified as COCs in the FFS for characterization of groundwater for evaluation of remedial action alternatives. The fate and transport of COCs in groundwater are discussed in the following paragraphs.

Dissolution and mobilization of metals by leaching of tailings or sediments by infiltrating waters are pathways by which metals can enter groundwater within OU10. Primary sources of metals within OU10 include the Oregon Gulch Tailings Impoundment, and tailings and stream sediments contained in the floodplain of Oregon Gulch (SMI/TerraMatrix, 1997).

Groundwater quality data is available for three of the water-bearing zones in OU1O: the intermediate alluvial aquifer, the perched saturated zone within the impoundment, and the perched alluvial aquifer downgradient of the tailings impoundment.

Table 6 presents water quality data for COCs, pH, and TDS, for the intermediate aquifer based on samples collected from monitoring wells OG1TMW1 and OG1TMW9 (Figure 5). Metal concentrations of groundwater samples collected from monitoring well OG1TMW1, located upgradient of the Oregon Gulch Tailings Impoundment, were below, detection limits except for arsenic which was detected at concentrations of 0.001 mg/L to 0.002 mg/L. The pH ranges from 7.72 to 8.33. Sulfate was detected at concentrations of 6 and 10 mg/L. Groundwater quality at monitoring well OG1TMW9, located northwest of the tailings impoundment, is also shown in Table 6. Metal concentrations in groundwater at OG1TMW9 are similar to concentrations observed at OG1TMW1. The pH of groundwater at OG1TMW9 was between 7.75 and 7.80 during the three sampling episodes. As shown in Table 6, the quality of the intermediate alluvial aquifer is characterized by alkaline pH and metal concentrations at or below the laboratory detection values. Concentrations of the intermediate alluvial aquifer are significantly less than groundwater concentrations for the perched alluvial aquifer in Oregon Gulch or the pore water contained within the Oregon Gulch Tailings Impoundment (SMI/TerraMatrix, 1997).

Table 7 provides a summary of water quality data for the perched saturated zone within the Oregon Gulch Tailings Impoundment, as represented by tailings monitoring wells OG1TMW4, OG1TMW5, and OG1TMW6A. Figure 5 shows the locations of these monitoring wells. Water samples collected from these monitoring wells indicate that the tailings pore water is acidic (pH ranges from 4.1 to 5.4) and contains elevated concentrations of dissolved arsenic, cadmium, lead, and zinc. Sulfate concentrations ranged from 9,220 mg/L to 30,300 mg/L. Referring to the water quality of the tailing seep previously provided in Table 3, the pH of the tailings seep (average pH is 2.9) is less than the pH of the perched water within the tailings (average pH is 4.8); however, average metal concentrations of the tailings seep are less than the tailings pore water by factors ranging from approximately 3 to 30 depending on the specific metal (SMI/TerraMatrix, 1997).

Table 8 summarizes the chemical analyses of groundwater samples collected from the perched alluvial aquifer as represented by monitoring wells OG1TMW8 and OG1TMW3. As shown on Figure 5, monitoring well OG1TMW8 is located near the toe of the tailings embankment, and monitoring well OG1TMW3 is located approximately 1,500 feet downstream of the toe of the embankment. The pH at OG1TMW8 ranged from 4.06 to 4.29, while the pH at OG1TMW3 was significantly lower ranging from 1.90 to 2.81. Sulfate concentrations at both monitoring wells were similar and ranged from 22,500 to 39,600 mg/L. Average concentrations of arsenic, cadmium, copper, and zinc were higher at OG1TMW3 than at OG1TMW8. Lead concentrations in the perched alluvial aquifer were typically lower at downgradient monitoring well OG1TMW3 as compared to OG1TMW8. Based on the comparison of concentrations at OG1TMW8 and OG1TMW3, concentrations of metals in the perched alluvial aquifer increased and pH decreased as groundwater migrated downgradient in Oregon Gulch (SMI/TerraMatrix, 1997).

The groundwater quality of the perched alluvial aquifer was also compared to the water quality of the tailings seep (Table 3) and tailings pore water within the impoundment (Table 7). Groundwater average metal concentrations at OG1TMW8, located near the toe of the tailings impoundment, were lower as compared to the average concentrations of the tailings seep and tailings pore water. The average pH of groundwater at OG1TMW8 was 4.2 as compared to the average pH of 2.9 for the tailings seep and 4.8 for the tailings pore water. In contrast, the average metal concentrations at OG1TMW3, located further downgradient in Oregon Gulch, were higher than the average metal concentrations of the tailings seep and tailings pore water, except for dissolved lead.

5.3.3.1 Groundwater-Surface Water Interaction

As previously discussed, surface water flows in Oregon Gulch are hydraulically connected and interact with the shallow, perched alluvial aquifer in Oregon Gulch. Portions of California Gulch have also been identified as losing or gaining stream reaches. Losing reaches are defined as areas where surface water recharges groundwater. Gaining reaches are defined as locations where groundwater discharges into surface water.

In the Hydrogeologic RI (Golder, 1996b), a gaining reach was identified in California Gulch generally from the confluences of Oregon Gulch and Starr Ditch with California Gulch to a distance of approximately 600 feet downstream. The load contributed from shallow groundwater in Oregon Gulch to this reach of California Gulch was estimated as discussed below.

Estimated loading for the constituents of concern contributed by groundwater in Oregon Gulch to California Gulch is presented in Table 9 The constituent loading rates were based on the average dissolved concentrations from samples collected from monitoring well OG1TMW3 and the estimated shallow groundwater discharge rate from Oregon Gulch. The average annual discharge of shallow Oregon Gulch groundwater to California Gulch surface flows was calculated in the FFS to be 2.8 gpm. The average loads contributed by Oregon Gulch groundwater were compared to the average loading at point CG-4 (Figure 5), the surface water sampling site in California Gulch downstream of the confluence with Oregon Gulch. Available data from sampling events between 1989 to October 1995 were used to calculate the average constituent loading rate at point CG-4.

The groundwater flow rate from Oregon Gulch of 2.8 gpm is approximately 0.3 percent of the average flow at CG-4 of 1,632 gpm. As shown in Table 9, shallow groundwater flow in Oregon Gulch was estimated to contribute the following percentages of loading at CG-4 in California Gulch: 50 percent of the arsenic load, 0.5 percent of the cadmium, 3 percent of the copper, 0.003 percent of the lead, 5.2 percent of the zinc, and 6.4 percent of the sulfate (SMI/TerraMatrix, 1997).

5.3.4 STREAM SEDIMENTS

Several studies have been conducted to evaluate the metal content in stream sediments in the California Gulch drainage. As part of these investigations, stream sediment samples were collected and analyzed. Sediment samples were collected at various surface water sample locations with California Gulch. Sediment sampling locations in the vicinity of Oregon Gulch are shown on Figure 5.

Sources of metal contamination to stream sediments in Oregon Gulch include the deposition of tailings eroded from the embankment of the Oregon Gulch Tailings Impoundment and the migration of acidic surface water and groundwater containing inorganic metals. Metals contained in runoff from the tailings embankment and in the tailings seep have contributed to metals loading of the stream sediments in Oregon Gulch. The stream sediments contain tailings and metal precipitates intermixed with native sediment.

Stream sediments in Oregon Gulch are subject to downstream transport during snowmelt runoff or storm events. In addition, metals absorbed to or precipitated onto stream sediments may serve as secondary soures where changes in the water chemistry cause these sorbed or precipitated metals to re-dissolve into surface water. Mechanisms for the releaase of metals from stream sediment into groundwater include direct leaching of stream sediments by groundwater, and leaching of metals absorbed or precipitated in stream sediments by surface water infiltrating into groundwater (SMI/TerraMatrix, 1997).

Metal concentrations of sediment samples collected in 1989 from Oregon Gulch during the California Gulch Hydrologic Investigation (WWL, 1990) are summarized in Table 10. Within Oregon Gulch, metal concentrations in stream sedimentss were observed to be the highest immediately downstream of the toe of the embankment where eroded tailings have been deposited (WWL, 1990). Metals concentrations were also elevated in the upper reaches of the south diversion ditch immediately downstream of the tailings impoundment where erosion along the southwest embankment has occurred.

Metal concentrations of stream sediment samples collected between 1989 and 1994 in Oregon Gulch and at sites in California Gulch upstream and downstream of Oregon Gulch are provided in Table 11. Metall concentrations in Oregon Gulch stream sediments at OG-1 were generally lower than concentraatiions of stream sediments in California Gulch at sampling locations CG-3 (upstream of Oregon Gulch) and CG-4 (downstream of Oregon Gulch). However, sulfate concentrations of Oregon Gulch stream sediments were higher than sulfate concentrations of stream sediments in California Gulch (SMI/TerraMatrix, 1997).

5.3.5 AIR

No air quality data has been collected within OU10. Prevailing winds in the Leadville area are predominately from the west-northwest and to a lesser extent from the northeast. Consequently, the predominant wind flow over the Oregon Gulch Tailings Impoundment is away from populated areas of Leadville (SMI/TerraMatrix, 1997).

5.4 HISTORIC AND CULTURAL RESOURCES

During the survey by Foothill Engineering Consultants (FEC, 1995), three cultural resources sites were identified within Oregon Gulch: (1) the Oregon Gulch Tailings Impoundment (Site 5LK382), (2) historic trash scatter in Oregon Gulch extending from the east side of County Road 6 to an upstream distance of approximately 470 feet (Site 5LK844), and (3) the gravel check dam located about 0.2 miles upstream of County Road 6 (Site 5LK850). Based on the results of the cultural resources survey, EPA determined that Site 5LK844 was eligible for nomination to the National Register of Historic Places (NRHP). The State Historic Preservation Office concurred with this determination. The 5LK844 site consists of a large historic trash scatter and depressions located in Oregon Gulch east of County Road 6, as shown on Figure 3. Artifacts on the 5LK844 site include glass, ceramics, tin cans, construction materials, and other miscellaneous items (FEC, 1995). Site 5LK844 is heavily disturbed by human activities and by the natural geomorphologic processes of Oregon Gulch. The Midland Railroad extended across the gulch in the middle portion of the 5LK844 site. A road to Georgia Gulch (to the south) crossed the site area, and a two-track dirt road also extended up the gulch along the north edge of the drainage. In addition, the area around the 5LK844 site has been used as a trash dump until the present time (FEC, 1995). Remedial actions in Oregon Gulch outside the boundaries of Site 5LK844 will not affect any known resources considered eligible for the NRHP. The Tailings Impoundment (Site 5LK382) and the gravel check dam (Site 5LK850) were determined not individually eligible for the NRHP (SMI/TerraMatrix, 1997).

A cultural resource inventory was also conducted by P-III (P-III, 1995) to survey access roads and a borrow area to be used during response activities. The survey did not discover historic sites or artifacts in the areas inventoried. Some modern trash and isolated debris were identified during the inventory; however, no discernible historic properties were encountered in the inventoried areas. P-III concluded that ground-disturbing activitiess in the areas inventoried would not affect any historic properties.

6.0 SUMMARY OF SITE RISKS

Baseline human health and ecological risk assessments characterize baseline risks at a site (risks that would exist if no action were taken). They provide the basis for remedial action and indicate the exposure pathways to be addressed. The following sections of the ROD summarize risk assessment information describing exposure pathways, contaminants, and potential risks at OU10.

6.1 HUMAN HEALTH RISKS

OU10 is zoned for industrial and mining use. There are no residents in OU10. OU10 is not used for any industrial purposes other than the Oregon Gulch Tailings Impoundment. Neither commercial or industrial workers are exposed to the tailings. Also, OU10 is private property and is not currently defined as a recreation area. Therefore, exposure pathways to humans do not currently exist in OU10.

6.2 ECOLOGICAL RISKS

Several baseline risk assessments have characterized ecological risks at OU10. These reports are as follows:

- Preliminary Ecological Risk Assessment for Oregon Gulch (OU10) (PERAOG) (Weston 1995a)
- Draft Baseline Aquatic Ecological Risk Assessment, California Gulch NPL Site (BARA) (Weston 1995b)
- Ecological Risk Assessment for the Terrestrial Ecosystem, California Gulch NPL Site, Leadville, Colorado (ERA) (Weston 1997)

The PERAOG (Weston 1995a) is a preliminary screening-level assessment of risk to aquatic and terrestrial ecosystems specifically related to contaminant sources in Oregon Gulch. Impacts of mine waste contamination on the aquatic ecosystem at the California Gulch NPL Site are characterized in the BARA (Weston 1995b). The ERA (Weston 1997) identifies potential risks to the terrestrial ecosystem from mine wastes within the California Gulch NPL Site.

6.2.1 CONTAMINANT IDENTIFICATION

Based on the information available (i.e. Section 5), media evaluated for potential ecological risks consist of tailings, surface soil associated with the tailings, ponded water, surface water, and sediments. It is unlikely that ecological receptors would be directly exposed to groundwater; therefore, groundwater is evaluated only in the context of loadings to surface water. All inorganic contaminants detected in site media, including arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, thallium, and zinc, were evaluated for potential ecological risks.

6.2.2 EXPOSURE ASSESSMENT

Five components are generally necessary for exposure to occur:

- A source of contamination (i.e., the tailings impoundment)
- A mechanism of chemical release (i.e., runoff)
- A retention or transport medium (i.e., surface water)
- A point of potential contact of the receptor with the contaminated medium (e.g., plants in soil)
- An exposure route at the contact point (i.e., ingestion, direct contact)

The primary source of metals in OU1O is the Oregon Gulch Tailings Impoundment. Release mechanisms of metals from the tailings impoundment to surface water and sediment include erosion of tailings from the embankment, surface water runoff, seep discharge, and loading by groundwater. Metals from the tailings impoundment are potentially released to groundwater by leaching and migration. Contaminants in stream sediment are potentially released by dissolution of metals into surface water and by leaching of metals into groundwater.

Potential terrestrial receptors in OU10 include terrestrial wildlife, birds, plants, and soil fauna. The stream in Oregon Gulch is generally dry, therefore, aquatic receptors do not exist for OU10. However, aquatic receptors in California Gulch and the Arkansas River could contact sediments and surface water impacted by contamination from OU10.

Potential exposure pathways to contaminated media in OU10 include: 1) ingestion of surface tailings by terrestrial receptors, 2) direct contact of terrestrial receptors to surface tailings and surface water, 3) ingestion of ponded surface water, surface water from the stream channel and diversion ditch, and surface water from seeps by terrestrial receptors, and 4) incidental ingestion of sediment by terrestrial receptors during ingestion of surface water.

Aquatic receptors in California Gulch and the Arkansas River could potentially be exposed to sediments and surface water impacted by OU10 contamination through 1) ingestion of surface water, sediments, and contaminated dietary items, and 2) direct contact with surface water and sediments.

The ERA (Weston, 1997) selected several terrestrial receptors to represent exposed terrestrial populations at the site. Terrestrial receptors selected for use in the ERA were blue grouse, mountain bluebird, American kestrel, red-tailed hawk, bald eagle, least chipmunk, mule deer, and red fox. Plants and soil fauna were also evaluated for contact with media.

The PERAOG (Weston 1995a) did not identify specific ecological receptors, rather, representative receptor groups were selected, consisting of passerine, raptor, small herbivore, large herbivore, small omnivore, and large omnivore receptors. Aquatic receptors in the Arkansas River and California Gulch were also evaluated for intake of contaminants from undiluted surface water and sediment from Oregon Gulch. Aquatic receptors were evaluated as one group.

Since aquatic life has not been identified in OU10 due to intermittent flow in Oregon Gulch, contaminant intake by aquatic receptors was not defined as a pathway for evaluation in the BARA (Weston 1995b). However, OU10 may contribute to contamination in California Gulch and the Arkansas River through metal loadings in surface water and sediment. Aquatic receptors in California Gulch and the Arkansas River may be at increased risk from contaminants contributed by Oregon Gulch.

Contaminant intake was calculated for representative terrestrial receptors using estimates of exposure (i.e., ingestion rate) combined with estimates of contaminant exposure point concentrations (the concentration of contaminant at the point of exposure). Maximum contaminant concentrations or the 95th percent upper confidence limit of the arithmetic mean were used as exposure point concentrations. Estimates of contaminant intake were used to evaluate potential risk to terrestrial receptors.

6.2.3 RISK CHARACTERIZATION

All of the risk assessments used the hazard quotient (HQ) approach to evaluate risk. In this approach, the exposure point concentration or the contaminant intake is divided by chemical-specific toxicity criteria. A HQ less than one indicates there is little potential for adverse effects to occur from exposure to a specific chemical via the exposure pathway evaluated. A HQ greater than one indicates a potential for risk but does not necessarily mean that adverse effects will occur. The sum of the HQs is the hazard index (HI).

For terrestrial receptors, contaminant intake for each receptor was divided by toxicity cniteria to obtain an HQ. Toxicological literature were reviewed to derive acceptable chemical intake values for birds and mammals, and acceptable media concentrations for plants and soil fauna. Resulting benchmark values were used as the toxicity criteria.

Aquatic macroinvertebrates, fish, and aquatic plants were assumed to be exposed directly to contaminants in surface water and sediments. Contaminant exposure point concentrations in surface water (dissolved concentrations) and sediments were compared to federal criteria such as the ambient water quality criteria (AWQC), state standards, or other toxicity criteria. Surface water and sediment criteria are designed to protect all aquatic species. HQs were obtained by division of the exposure point concentration by the toxicity criteria.

Results of risk characterization in the PERAOG indicated that terrestrial wildlife and birds are at risk from exposure to contaminants in tailings, surface water, and sediments in OU10. Table 12 summarizes the HIs for terrestrial receptors at OU10 for all exposure pathways and all contaminants. As indicated by risk estimates in the PERAOG. HIs based on average exposure range from 33 for large omnivores to 2,160 for passerines. For reasonable maximum exposure (RME), HIs range from 46 for large omnivores to 3.601 for passerines. Although not all HQs exceed one, all HIs are greater than one, indicating that all terrestrial receptors are at potential risk from exposure to one or more contaminants at OU10.

Table 13 summarizes the HQs presented in the PERAOG for aquatic life in California Gulch and/or the Arkansas River exposed to undiluted contaminant concentrations in surface water from Oregon Gulch. As shown in Table 13, several HQs exceed one for both average and RME intake. The maximum HQ from comparison of acute AWQC to average intake is 3,715 for zinc. The maximum HQ from comparison of chronic AWQC to average intake is 4,053 for zinc. HQs based on RME intake are correspondingly greater. The maximum HQs from comparison of acute and chronic AWQC to RME intake is 6,313 and 6,887 (both for zinc), respectively. These HQs indicate that aquatic receptors in California Gulch and/or the Arkansas River are at potential risk from exposure to contaminants in undiluted surface water from Oregon Gulch.

Table 14 provides the HQs presented in the PERAOG for aquatic life in California Gulch and/or the Arkansas River exposed to undiluted contaminant concentrations in sediments from Oregon Gulch. As shown in this table, several HQs exceed one for both average and RME intake. The maximum HQ for average exposure is 14, for copper. The maximum HQ for RME intake is 27, for arsenic. These HQs indicate that aquatic receptors in California Gulch and/or the Arkansas River are at potential risk from exposure to contaminants in sediments from Oregon Gulch.

The characterization of risks presented in the ERA indicated that terrestrial wildlife and birds are at risk from exposure to contaminants in tailings, surface water, and sediments in OU10. Table 15 summarizes the HIs presented in the ERA for terrestrial receptors at OU10 for all exposure pathways and all contaminants. HIs exceed one for the blue grouse, mountain bluebird, American kestrel, and least chipmunk. This indicates there is potential risk to terrestrial receptors at OU10 from exposure to contaminants.

The BARA identifies the impact of mine waste contamination on the aquatic ecosystem at the California Gulch Superfund Site. Mine waste, including waste rock, tailings piles, and smelter wastes in the form of slag, flue dust, and stack emissions have caused increased metal loadings to surface water and sediments in the California Gulch area and the Arkansas River. The physical limitations of Oregon Gulch preclude the support of aquatic life, therefore, risk evaluations in the BARA were focused on California Gulch and the Arkansas River. Risk to aquatic life was not calculated for Oregon Gulch. Surface water and sediment data presented in the BARA indicate that Oregon Gulch is a contributing source to the ongoing metal pollution of surface water and sediment in California Gulch and the Arkansas River. Contaminants in surface water and sediments in California Gulch and the Arkansas River present a risk to aquatic receptors. Oregon Gulch contributes to this risk; however, the portion contributed by Oregon Gulch was not defined in the BARA.

6.3 SUMMARY

The results of the risk assessments pertinent to OU10 indicate the following media and exposure pathways present potential risk to terrestrial and/or aquatic receptors:

- Ingestion of surface tailings by terrestrial receptors

- Direct exposure of plants and soil fauna to surface tailings

- Ingestion of surface water and accompanying incidental ingestion of sediment by terrestrial receptors

- Direct exposure of aquatic receptors to surface water downstream of OU10

- Direct exposure of aquatic receptors to sediment downstream of OU10

The following conclusions may be reached from results presented in the ERA, BARA, and PERAOG:

- The tailings pile presents a potential risk to terrestrial receptors and to downstream aquatic receptors through runoff, etc.

- Surface water presents a potential risk to terrestrial receptors and to the aquatic ecosystem downstream of OU10

- Sediment presents a potential risk to terrestrial receptors and to the aquatic ecosystem downstream of 0U10

- OU10 is a contributing source of contaminants to downstream surface water and sediment and therefore contributes to the potential risk in California Gulch.

7.0 DESCRIPTION OF ALTERNATIVES

A wide range of cleanup options were considered in the Screening Feasibility Study (SFS) (EPA, 1993). Some of the alternatives were eliminated during preliminary screening because they would not effectively address contamination, could not be implemented, or would have had excessive costs. Remedial action alternatives for OU10 that were retained after screening alternatives from the SFS for stream sediments were evaluated in the EE/CA and the alternatives for the impounded tailings were evaluated in the FFS. All of the alternatives were evaluated using the nine criteria required by the NCP and six additional performance criteria required by the WAMP as a part of the CD. This evaluation is described in the next section.

Three categories of alternatives were evaluated in the EE/CA for Oregon Gulch Stream Sediment (SMI/TerraMatrix, 1995b): (1) channel alternatives, (2) floodplain stabilization alternatives, and (3) cultural resource alternatives. Two channel alternatives, a 500-year channel and a 10-year channel, were evaluated for their potential to stabilize the channel in Oregon Gulch below the tailing impoundment. Four floodplain stabilization alternatives were considered to addrss the area outside the newly constructed channel. These altermatives are: (1) stabilization in place, (2) cover in place, (3) excavation and reconstruction, and (4) treatment in place. Four remedial action alternatives were developed to address the remediation at Cultural Resource Site 5LK844 while avoiding adverse impacts to the site. These alternatives are: (1) no action, (2) avoidance, (3) covering, and (4) reconstructing the existing channel. In conjunction with these alternatives, a sediment control pond was proposed for construction in Oregon Gulch downstream of the toe of the tailing impoundment to protect the stream channel from eroded tailing and sediment.

A brief description of the five clean up alternatives that were considered in the FFS for the Oregon Gulch OU10 impounded tailings (SMI/TerraMatrix, 1997) is provided below.

Alternative 1: No Action

Estimated capital and operating cost: $0
Implementation time: Immediate

No remediation would take place under this alternative. This is the "no action" alternative required under CERCLA and is used as a baseline against which other alternatives are evaluated. The existing impoundment is susceptible to erosion and migration of tailings as well as leaching of metals from tailings. Existing diversion ditches reduce the amount of run-on to the tailings surface. A sediment control dam, built as part of the Oregon Gulch Stream Sediment EE/CA (SMI/TerraMatrix, 1995b), captures sediment from runoff from the northwest embankment.

Alternative 2: Simple Vegetated Cover

Estimated capital and operating cost: $1,830,000
Implementation time: 1 to 2 years

This alternative would consist of regrading the tailings impoundment surface and embankment, and placing a soil cover. The simple soil cover would consist of a structural fill layer comprised of regraded tailings and borrow soil followed by a 3-inch-thick layer of granular limestone. The limestone would be overlain by an 18-inch-thick growth media layer, including soil amendments. The cover would be revegetated with a mixture of native and introduced species adapted to the location (SMI/TerraMatrix, 1997).

The tailings embankments would be regraded to a slope of 2.75:1 or flatter to increase stability and meet WAMP criteria (USDC, 1994). The final design of the regraded embankment slope would be determined during the remedial design based on available data that may be supplemented by laboratory testing of site soils. The tailings impoundment surface would be regraded to eliminate ponding and achieve positive drainage into a low-permeability diversion ditch located adjacent to the east side of the impoundment. The diversion ditch located adjacent to the east side of the impoundment would drain to the south diversion ditch. This alternative also includes a provision to collect and treat the seep currently discharging at the toe of the impoundment until the seep no longer impacts surface water quality.

Alternative 3: Clay Layer Vegetated Cover

Estimated capital and operating cost: $1,980,000
Implementation time: 1 to 2 years

This alternative would consist of regrading the tailings impoundment surface and embankment, and placement of a vegetated cover with a low-permeability clay layer on the top of the impoundment and a simple vegetated cover on the embankment side slopes. The low-permeability clay cover placed on the top of the impoundment would consist of a structural fill layer made up of regraded tailings and borrow soil, a 12-inch-thick low-permeability clay layer, a 6-inch-thick sand drainage layer, a geotextile, an 18-inch-thick random fill layer, and a vegetated 12-inch-thick growth media layer with soil amendments. The cover placed on the embankments would be similar to the cover used with Alternative 2. This cover would consist of 3 inches of granular limestone overlain by an 18-inch-thick growth media layer, including soil amendments and vegetation (SMI/TerraMatrix, 1997).

The tailings embankments would be regraded to a slope of 2.75:1 or flatter to increase stability and meet WAMP criteria (USDC, 1994). The final design of the regraded embankment slope would be determined during the remedial design based on available data that may be supplemented by laboratory testing of site soils. The tailings impoundment surface would be regraded to eliminate ponding and achieve positive drainage into a low-permeability diversion ditch located adjacent to the east side of the impoundment. The diversion ditch located adjacent to the east side of the impoundment would drain to the south diversion ditch. To reduce the potential for groundwater entering the tailing impoundment, an upgradient groundwater interceptor trench would be constructed in the Oregon Gulch channel upstream of the tailing impoundment. Collected groundwater would drain to the south diversion ditch. This alternative also includes a provision to collect and treat the seep currently discharging at the toe of the impoundment until the seep no longer impacts surface water quality.

Alternative 4: Soil Cover with Geosynthetic Barrier

Estimated capital and operating cost: S2,270,000
Implementation time: 1 to 2 years

This alternative would consist of regrading the tailings impoundment surface and embankments, and placement of a soil cover with a geosynthetic barrier layer on the top of the impoundment and a simple vegetated cover on the tailings embankments. The tailings embankments would be regraded to a slope of 2.75:1 or flatter to increase stability and meet WAMP criteria (USDC, 1994). The final design of the regraded embankment slope would be determined during the remedial design based on available data that may be supplemented by laboratory testing of site soils (SMI/TerraMatrix, 1997).

The impoundment top surface would be regraded to achieve positive drainage from the surface into a low-permeability diversion ditch located adjacent to the east side of the impoundment. The diversion ditch located adjacent to the east side of the impoundment would drain to the south diversion ditch. The cover placed on the top of the impoundment would consist of a structural fill layer consisting of regraded tailings or borrow soil, a geosynthetic barrier, a sand drainage layer, a geotextile, and an 18-inch-thick layer of plant growth media layer.

The simple cover placed on the embankments would be similar to the cover specified in Alternative 2. This simple cover would consist of 3 inches of granular limestone placed over the regraded tailings followed by an 18-inch-thick growth media layer, including soil amendments and establishing vegetation.

To reduce the potential for groundwater entering the tailing impoundment, an upgradient groundwater interceptor trench would be constructed in the Oregon Gulch channel upstream of the tailing impoundment. Collected groundwater would drain to the south diversion ditch. This alternative also includes a provision to collect and treat the seep currently discharging at the toe of the impoundment until the seep no longer impacts surface water quality.

Alternative 5: Multi-Layer Rock and Soil Cover with Geosynthetic Barrier

Estimated capital and operating cost: $2,540,000
Time to implement: 1 to 2 years

This alternative includes regrading the tailings impoundment surface and embankments, and placement of a multi-layer cover with a geosynthetic barrier layer. The tailings embankments would be regraded to slopes of 3:1 or flatter to enhance stabilization, and the top of the impoundment surface would be regraded to achieve positive drainage from the surface into a low-permeability diversion ditch located adjacent to the east side of the impoundment. The diversion ditch located adjacent to the east side of the impoundment would drain to the south diversion ditch. The cover placed on the impoundment (including the embankments) would consist of structural fill consisting of borrow or suitable tailings, a geosynthetic barrier layer, and a geocomposite drainage layer. An 18-inch-thick layer of plant growth media would be placed on the top of the impoundment over the geocomposite drainage layer. On the embankments, an 18-inch-thick layer of random fill overlain with an erosion-resistant, 6-inch-thick gravel layer would be placed over the geocomposite drainage layer. The regraded and covered surface would eliminate ponding on the impoundment and allow runoff to drain into the diversion ditch.

The tailings embankment would be regraded to a 3:1 slope or flatter to increase stability and meet WAMP criteria (USDC, 1994). The final design of the regraded embankment slope would be determined during the remedial design based on available data which may be supplemented by laboratory testing of site soils and samples of specific geosynthetic cover components (SMI/TerraMatrix, 1997). The top surface of the tailings would be regraded to a slope of 2 percent towards the diversion ditch located on the east side.

To reduce the potential for groundwater entering the tailing impoundment, an upgradient groundwater interceptor trench would be constructed in the Oregon Gulch channel upstream of the tailing impoundment. Collected groundwater would drain to the south diversion ditch. This alternative also includes a provision to collect and treat the seep currently discharging at the toe of the impoundment until the seep no longer impacts surface water quality.

8.0 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

Section 300.430(e)(9) of the NCP requires that the EPA evaluates and compares the remedial cleanup alternatives based on the nine criteria listed below. The first two criteria, (1) overall protection of human health and the environment and (2) compliance with applicable or relevant and appropriate requirements (ARARs) In Appendix A, are threshold criteria that must be met for the Selected Remedy. The Selected Remedy must then represent the best balance of the remaining primary balancing and modifying criteria. In addition the cleanup alternatives were evaluated using six performance criteria specified in the WAMP (USDC, 1994) to assist in evaluating the effectiveness of each alternative.

8.1 NCP EVALUATION AND COMPARISON CRITERIA

8.1.1 THRESHOLD CRITERIA

1. Overall protection of human health and the environment addresses whether or not a remedy provides adequate protection and describes how potential risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or Institutional Controls.

2. Compliance with ARARs addresses whether or not a remedy will comply with identified federal and state environmental and siting laws and regulations.

8.1.2 PRIMARY BALANCING CRITERIA

3. Long-term effectiveness and permanence refers to the ability of a remedy to maintain reliable protection of human health and the environment over time.

4. Reduction of toxicity, mobility and volume through treatment refers to the degree that the remedy reduces toxicity, mobility, and volume of the contamination.

5. Short-term effectiveness addresses the period of time needed to complete the remedy and any adverse impact on human health and the environment that may be posed during the construction and implementation period until cleanup goals are achieved.

6. Implementability refers to the technical and administrative feasibilities of a remedy, including the availability of materials and services needed to carry out a particular option.

7. Cost evaluates the estimates capital costs, operation and maintenance (O&M) costs, and present worth costs of each alternative.

8.1.3 MODIFYING CRITERIA

8. State acceptance indicates whether the State (CDPHE), based on its review of the information, concurs with, opposes, or has no comment on the preferred alternative.

9. Community acceptance is based on whether community concerns are addressed by the Selected Remedy and whether or not the community has a preference for a remedy.

8.2 WAMP PERFORMANCE CRITERIA

Additional site-specific criteria beyond the required NCP criteria have been developed for evaluating remedial alternatives for OU10. These criteria are described in the WAMP attached as Appendix D to the Consent Decree for the California Gulch Site. The six WAMP (USDC, 1994) criteria described below have assisted in the evaluation of the effectiveness of each proposed alternative:

1. Surface Erosion Stability: Remedial alternatives for source material will ensure surface erosion stability through the development of surface configurations and implementation of erosion protection measures. The remedial design will meet the following criteria:

   a. Erosional releases of waste material are predicted by use of all or some of the following procedures: the Revised Universal Soils Loss Equation (RUSLE), wind erosion soil loss equation (Woodruff and Siddoway, 1965), and the procedures set forth in the U.S. Nuclear Regulatory Commission's Staff Technical Position, Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings sites (NRC,1990) for site-specific storm flow conditions set forth in 1.b below.

   b. Remediated surfaces located within the 500-year floodplain will be stable under 500-year, 24-hour, and 2-hour storm events. Remediated surfaces located outside the 500-year floodplain will be stable under 100-year, 24-hour, and 2-hour storm events. On source embankments or where the slope of the reconstructed source is steeper than 5:1 (Horizontal: Vertical), surface flow will be concentrated by a factor of 3 for purposes of evaluating erosion stability.

2. Slope Stability: Source remediation alternatives will ensure geotechnical stability through the development of embankments or slope contours. The remedial design will meet the following criteria:

   a. Impounding embankments will be designed with a Factor of Safety (Safety Factor) of 1.5 for static conditions and 1.0 for pseudo-static conditions.

   b. Recontoured slopes will be designed with a Safety Factor of 1.5 for static conditions and 1.0 for pseudo-static conditions.

   C. Analysis of geotechnical stability will be performed using an acceptable computer model. Material and geometry input parameters will be obtained from available data.

3. Flow Capacity and Stability: Remedial alternatives utilizing retaining structures, diversion ditches, or reconstructed stream channels will ensure sufficient capacity and erosional stability of those structures. The remedial design will meet the following

criteria:

a. Capacity: Diversion ditches will be sized to convey the 100-year, 24-hour, and 2-hour storm events. Reconstructed stream channels will be sized to convey flow equal to or greater than the flow capacity immediately upstream of the reconstruction.

b. Stability: Erosional release of waste material from ditches, stream channels, or retaining structures will be determined by either or both of the following models: U.S. Army Corps of Engineers Hydrologic Engineering Center HEC-1(COE, 1991) and HEC-2 (COE, 1990) models.

   1) Diversion Ditches and Reconstructed Stream Channels: Remedial surfaces located within the California Gulch 500-year floodplain will be designed to be stable under flows resulting from 500-year, 24-hour, and 2-hour storm events. Remedial construction outside the 500-year floodplain will be designed to withstand flows resulting from the 100-year, 24-hour, and 2-hour storm events. Reconstructed team channels will be configured to the extent practicable to replicate naturally occurring channel patterns.

   2) Retaining Structures: Structures such as gabions, earth dikes, or riprap will be designed to be stable under the conditions stated above under item 3.b.1 for the diversion ditch or stream channel with which the structure is associated. If riprap is to be placed in stream channels or ditches, the riprap will be sized utilizing one of the following methods:

      - U.S. Army Corps of Engineers (COE, 1991);
      - Safety Factor Method (Stevens and Simons, 1971);
      - Stephenson Method (Stephenson, 1979);
      - Abt/CSU Method (Abt, et. al., 1988).

      Selection of one of these methods will be based on the site-specific flow and slope conditions encountered.

4. Surface and Groundwater Loading Reduction: Remedial alternatives will ensure reduction of mass loading of COCs (including TSS and sulfate), as defined in the Draft Final Terrestrial Risk Assessment (see WAMP [USDC, 1994]), and change in pH, resulting from run-on, run-off, and infiltration from source areas. The FFS will incorporate the following:

   a. For each source of contamination evaluated in the FFS, the present mass loading of COCs (including TSS and sulfate) will be calculated for both surface and groundwater using scientifically accepted methods. Present pH measurements will also be calculated.

   b. For each source of contamination evaluated in the FFS, the net loading reduction of COCs (including TSS and sulfate) and change in pH resulting from implementation of each remedial alternative shall be calculated for surface and groundwater using scientifically accepted methods.

5. Terrestrial Ecosystem Exposure: Evaluation of remedial action alternatives with respect to reduction of risk to the terrestrial ecosystems within each OU should be based on area-wide estimates of risk to receptor populations. Exposure estimates for assessing this risk should consider factors that affect the frequency and duration of contact with contaminated media, such as: (1) the concentrations and areal extent of contamination, and (2) the effect of home range on the amount of time a given species will spend in contact with contaminated media. For each source of contamination evaluated in the FFS, the reduction of the potential exposure predicted to result from the implementation of each remedial action alternative will be compared to the present potential exposure predicted by the terrestrial ecosystem risk assessment, as follows:

   a. For each source of contamination evaluated in the FFS, the present risk due to exposure as defined in the terrestrial ecosystem risk assessment will be estimated for soil, each source of contamination, and ponded surface water associated with each source of contamination.

b. For each source of contamination evaluated in the FFS, reduction of exposure and ecological risk resulting from the implementation of each remedial alternative will be estimated for soil and the media types above. The potential exposure predicted to result from implementation of each remedial alternative will be compared to the present potential baseline exposure predicted by the terrestrial ecosystem risk assessment.

6. Non-residential Soils: Non-residential soils will be addressed in the FFS. These non-residential soils are in areas zone agricultural/forest, highway/business, and industrial/mining. The non-residential areas within the OU will be evaluated in the FFS consistent with current and likely future land use.

8.3 EVALUATING THE ALTERNATIVES WITH THE NCP CRITERIA

A comparative analysis of the channel and floodplain remedial action alternatives for the stream sediments in Oregon Gulch was performed in the EE/CA and subsequently summarized in the Action Memorandum (EPA, 1995). The EE/CA found that the 10-year channel alternative and the 500-year channel alternative would both achieve RAOs and comply with ARARs. The long-term effectiveness and permanence of the two channel alternatives would also be similar. The 10-year channel alternative, however, is less costly and less difficult to implement than the 500-year channel alternative.

The EE/CA and Action Memorandum also evaluated four floodplain alternatives. The four alternatives achieve RAOs to varying degrees. The excavation and reconstruction alternative offered the greatest degree of overall protection to the environment in controlling erosion and reducing leaching of metals to groundwater and surface water. The excavation and reconstruction alternative also provided greater longterm effectiveness and permanence since sediments and miscellaneous tailing within the 500-year floodplain would be removed. All four floodplain alternatives would provide similar performance based on implementability. The estimated cost of the floodplain alternatives in conjunction with the 10-year channel alternative ranged from $112,000 for the stabilization in place alternative to $154,00 for the treatment in place alternative.

Of the cultural resource alternatives analyzed in the EE/CA, reconstructing the existing channel offered the greatest degree of overall protection to the environment by eliminating erosion and leaching of metals to groundwater and surface water and is less costly and less difficult to construct than either the avoidance or covering alternatives. The no action alternative was presented as a baseline for comparison the other three alternatives.

What follows is a brief summary of the evaluation and comparison of the Oregon Gulch Tailings Impoundment alternatives. Additional details evaluating the alternatives are presented in the FFS. This section evaluates the Oregon Gulch OU10 tailings impoundment alternatives against the nine NCP criteria. Table 16 provides a comparison of the five remedial action alternatives and the nine NCP criteria. Information for this section was obtained from the FFS for Oregon Gulch OU10 (SMI/TerraMatrix, 1997).

8.3.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

This criterion is based on the level of protection of human health and the environment afforded by each alternative. All of the alternatives, except Alternative 1 (No Action), would provide adequate protection of human health and the environment. Because the "no action" alternative is not protective of human health and the environment, it is not considered further in this analysis as an option for this site.

Although tailings materials and contaminated soils would remain on site, residual risks would be reduced under all action alternatives (except No Action) to achieve protection of human health via:

- The use of engineered covers to provide a barrier to wastes; and/or

- The use of revegetated treatment techniques to reduce the surface erosion.

Alternatives 2 through 5 provide overall protection of human health and the environment by meeting the following remedial action objectives (RAOs) defined for impounded tailings in the SFS:

- Control airborne transport of tailings particles;
- Control erosion of tailings materials and deposition in local water courses;
- Control leaching and migration of metals from tailings into surface water; and
- Control leaching and migration of metals from tailings into groundwater.

The primary difference between the alternatives is the increased protectiveness provided by covers with a geosynthetic barrier (Alternatives 4 and 5). Alternatives 4 and 5 would provide a higher level of infiltration reduction than the other alternatives. Alternative 5 would offer the greatest erosional stability and the greatest reduction in infiltration since the geosynthetic barrier would be installed over the entire area of the regraded impoundment (top surface and embankment slopes), as compared to only on the top surface for Alternative 4.

8.3.2 COMPLIANCE WITH APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

This criterion is based on compliance with the ARARs presented in Appendix A. Alternatives 2 through 5 would comply with all of the ARARs.

8.3.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

Depending on the specific remedial action alternative, Alternatives 2 through 5 would provide good to excellent long-term effectiveness and permanence. All of the surfaces for Alternative 2 through 5 provide for positive drainage from the surface to the diversion ditches and would be resistant to erosion. In comparison to the other alternatives, Alternative 5 would provide the highest level of permanence and long-term effectiveness. The rock cover surface on the embankment slopes for Alternative 5 would be erosion resistant, and long-term maintenance requirements would be minimal.

8.3.4 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

This criterion is based on the treatment process used; the amount of contamination destroyed or treated: the reduction of toxicity, mobility, and volume; the irreversible nature of the treatment; the type and quantity of residuals remaining; and the statutory preference for treatment. Alternatives 2 through 5 would all greatly reduce the mobility of the tailings (and metals) by regrading the surface and constructing the cover. However, toxicity and volume of the tailings Would be unaffected by these alternatives. In addition these alternatives would not comply with the statutory preference for treatment.

8.3.5 SHORT-TERM EFFECTIVENESS

This criterion is based on the degree of community and worker protection offered, the potential environmental impacts of the remediation, and the time until the remedial action is completed. Additional risk to the community during implementation of Alternatives 2 through 5 may result from dust emissions and increased road traffic. The topography surrounding the remediation area and the prevailing wind directions in the area (predominantly from the northwest) are conducive to natural abatement of short-term risk to the community from these alternatives. Furthermore, short-term risk factors could be effectively managed with standard engineering controls during construction. Dust abatement is a commonly practiced construction method. Additional traffic would be light and limited to private roads in the immediate vicinity of Oregon Gulch. The borrow source for construction materials is adjacent to the impoundment thus minimizing the haul distance.

Risk to workers during implementation of those alternatives may result from dust inhalation, contact with contaminated materials, and other industrial safety hazards. Dust generation would be mitigated using standard construction site watering and dust control practices. Contact with tailings by trained remediation workers would be minimal, because appropriate safety measures would be utilized.

Impacts to the environment during implementation of these remedial actions could potentially result from accidental discharge of runoff with suspended solids from tailings disturbed during construction. Potential problems would be minimized through the use of sediment control measures, including the existing sediment control pond downstream of the impoundment.

8.3.6 IMPLEMENTABILITY

This criterion is based on the ability to perform construction and implement administrative actions. The construction technologies used in Alternatives 2 through 5 are commonly used and widely accepted. Materials and personnel would be readily available for this type of work. The geosynthetic installation (Alternatives 4 and 5) may require specialized equipment and trained personnel.

The administrative feasibility of these alternatives would be good. Compliance with statutory limits would not be necessary since the selected remedial action would not be CERCLA fund-financed. Construction permits would not be necessary since all the work would occur on site. Res-Asarco joint venture and Resurrection own a majority of the land area within OU10 including the adjacent haul road and the majority of the borrow area (BLM has jurisdiction of a small portion), so obtaining access from land owners would not be an issue.

8.3.7 COST

This criterion evaluates the estimated capital, O&M and present worth costs of each alternative. Present worth costs range from $1.83 million (Alternative 2) to $2.54 million (Alternative 5). The present worth of post-removal site control costs for a 30-year period were calculated assuming a 7 percent discount rate.

Alternative 2: Simple Vegetated Cover

The estimated cost for this alternative would be $1.83 million. Estimated cost details are summarized in Table 17.

Alternative 3: Clay Layer Vegetated Cover

The estimated cost for this alternative would be $1.98 million. Estimated cost details are summarized in Table 18.

Alternative 4: Soil Cover with Geosynthetic Barrier

The estimated cost for this alternative would be $2.27 million. Estimated cost details are summarized in Table 19.

Alternative 5: Multi-Layer Rock and Soil Cover with Gcosynthetic Barrie

The estimated cost for this alternative would be $2.54 million. Estimated cost details are summarized in Table 20.

8.3.8 STATE ACCEPTANCE

The State has been consulted throughout this process and concurs with the Selected Remedv.

8.3.9 COMMUNITY ACCEPTANCE

Public comment on the RI/FS and Proposed Plan was solicited during a formal public comment period extending from March 19 to April 18, 1997. It is assumed that the community is generally supportive of EPA's Multi-Layer Rock and Soil Cover with Geosynthetic Barrier alternative since no comments were received during the formal public comment period.

8.4 EVALUATING THE ALTERNATIVES WITH THE WAMP CRITERIA

A comparative analysis of the channel and floodplain remedial action alternatives for the stream sediments in Oregon Gulch using the WAMP criteria was performed in the FFS. The Action Memorandum implemented the Removal Action for the stream sediments (EPA, 1995).

All channel, floodplain, and cultural resource alternatives would comply with WAMP criteria for surface erosion stability. The loading reduction for the channel alternatives were determined to be similar. Of the four floodplain alternatives, the cover in place alternative and the excavation and reconstruction alternative is predicted to provide a slightly higher predicted reduction in surface and groundwater flows. The cover in place alternative and the excavation and reconstruction alternative would also eliminate the risk to the terrestrial ecosystem by covering or removing the miscellaneous tailing and stream sediment. The predicted loading reductions and reduction in terrestrial ecosystem are similar for the cultural resource alternatives. Non-residential soils have not been identified as a source of contamination within OU10.

What follows is a brief summary of the agencies' evaluation and comparison of Oregon Gulch Tailings Impoundment alternatives against the six WAMP criteria. Additional details evaluating the alternatives are presented in the FFS. Table 21 presents a comparison of the ability of the five remedial action alternatives to achieve WAMP criteria. Information for this section was obtained from the FFS for Oregon Gulch OU10 (SMI/TerraMatrix, 1997).

8.4.1 SURFACE EROSION STABILITY

This criterion evaluates surface erosion stability through the development of surface configurations and implementation of erosion protection. All of the alternatives, except Alternative 1 (No Action), would achieve the erosional stability criteria, defined by the WAMP, with vegetative or rock covers and would reduce the existing loading of metals to surface or groundwater. Because the "no action" alternative does not provide erosional stability, it is not evaluated further in this analysis as an option for this site. Alternative 5 would provide the highest level of erosional stability.

8.4.2 SLOPE STABILITY

This criterion evaluates geotechnical stability through the development of embankments or slope contours to meet factors of safety criteria defined by the WAMP. Alternatives 2 through 4 would provide embankment slopes regraded to 2.75:1 or flatter to meet WAMP criteria. Alternatives 5 Would provide embankment slopes regraded to 3:1 or flatter to meet WAMP criteria.

8.4.3 FLOW CAPACITY AND STABILITY

This criterion evaluates the capacity and erosional stability of retained structures, diversion ditches, or reconstructed stream channels. Alternatives 2 through 5 would provide diversion ditches around the perimeter of the impoundment to be sized to convey the 100-year, 24-hour storm and be erosionally stable according, to WAMP criteria. The channels would be stabilized using vegetation, riprap, concrete, or several manufactured channel reinforcement products.

8.4.4 SURFACE WATER AND GROUNDWATER LOADING REDUCTION

This criterion evaluates the extent to which an alternative would ensure the reduction of mass loading of COCs resulting from run-on, run-off, and infiltration from source areas.

The predicted reductions in surface water loading and groundwater loading were calculated for each alternative, and are summarized in Table 21. The reduction of loading was calculated by comparing existing conditions to predicted conditions for each alternative. The covers would reduce loading by reducing or eliminating surface water contact with tailings and by reducing infiltration.

Alternatives 2 through 5 would provide a similar reduction in surface water loading. For Alternatives 2 through 5, surface water loading is predicted to be reduced from current loading conditions by approximately 89 percent to 100 percent, depending on the contaminant of concern. As shown in Table 21, the predicted reduction in groundwater loading ranges from 84.4

percent for Alternative 2 to 99.8 percent for Alternative 5 since each alternative reduces infiltration by a different amount.

8.4.5 TERRESTRIAL ECOSYSTEM EXPOSURE

This criterion evaluates the ability of each alternative to reduce risk to the terrestrial ecosystem within OU10. Each of the covers for Alternatives 2 through 5 would virtually eliminate the risk to the terrestrial ecosystem by isolating the tailings and removing the existing surface water pond.

8.4.6 NON-RESIDENTIAL SOILS

This criterion is not applicable. The sources of contamination at OU10 are miscellaneous tailings and stream sediment, not non-residential soils. Non-residential soils are not a source of contamination within OU10.

9.0 SELECTED REMEDY

An Action Memorandum (EPA, 1995) was issued on August 4, 1995 by the EPA that selected the following as the removal action for stream sediments within OU10:

Channel Alternative: 10-Year Channel. This alternative consists of constructing a channel capable of conveying the 10-year flood and stabilizing both the channel and the overbank area inundated during the 500-year flood. Channel construction will include excavating sediment to an average depth of 1.5 feet, mixing limestone in the first foot of subsoil underlying the channel, installing a geotextile, and placing riprap.

Stabilization Alternative: Excavation and Reconstruction. This alternative controls the release of contaminants by stabilizing the area outside the 100-year channel within the 500-year flood plain of Oregon Gulch. This alternative consists of: (1) excavating a 1-foot-thick layer of sediment, (2) transporting the excavated sediment to the Oregon Gulch Tailing Impoundment, and (3) re-establishing the excavated area of the gulch by regrading, placement of a 1-foot-thick layer of fill in the excavated area, amending the soil, and revegation.

Cultural Resource Alternative: Reconstruct Existing Channel. This alternative consists of removing stream sediment in the existing channel within Site 5LK844 to an average depth of 1.5 feet, mixing limestone in the first foot of subsoil underlying the channel, and stabilizing the channel with riprap for the 500-year flood. Excavation within the disturbed area of the existing channel will not disturb cultural resources.

A Final Removal Action Design Report (SMI/TerraMatrix, 1995c) was submitted to the EPA on August 28, 1995, and a Removal Action Work Plan (SMI/TerraMatrix, 1995d) providing an implementation plan was submitted on September 8, 1995. Implementation of the removal action was initiated during the fall of 1995 and was completed in the fall of 1996.

Based upon consideration of CERCLA requirements, the detailed analysis of alternatives, and public comments, EPA has determined that the Multi-Layer Rock and Soil Cover with a Geosynthetic Barrier alternative presented in the Proposed Plan, with no modifications, is the appropriate remedy for the Oregon Gulch Tailings Impoundment within OU10. This Selected Remedy will reduce risk to human health and the environment through the following:

- Provides the highest level of permanence and long-term effectiveness with the greatest reduction of infiltration into the tailings impoundment.

- Meets or exceeds all of the stability requirements predicated in the WAMP and minimizes the present risk to the terrestrial ecosystem. In addition, the cover proposed in the Selected Remedy exceeds the other alternatives in its ability to reduce the loading of contaminants to the surface water and the groundwater.

- Eliminates airborne transport of tailings particles and minimizes both the erosion of tailings materials and deposition into local water courses and the leaching and migration of metals into groundwater and surface water.

- Controls the risks defined by the risk assessment including ingestion of surface tailings by terrestrial wildlife, contact of plants and soil fauna with surface tailings, and ingestion of surface water by wildlife.

The Selected Remedy best meets the entire range of selection criteria and achieves, in EPA's determination, the appropriate balance considering site-specific conditions and criteria identified in CERCLA, the NCP and the WAMP, as provided in Section 10.0, Statutory Determinations.

9.1 REMEDY FOR THE OREGON GULCH TAILINGS IMPOUNDMENT

The Selected Remedy would consist of regrading the impoundment surface to provide positive drainage and flattening the embankment side slopes to 3:1 or milder. A geosynthetic barrier would be installed over a structural fill layer to control infiltration over the entire regraded impoundment (top and side slopes), followed by a geocomposite drainage layer (Figure 6). An 18-inch-thick vegetated soil layer will be placed on the top of the geocomposite drainage layer. On the side slopes, an 18-inch-thick layer of random fill overlain with an erosion-resistant 6-inch-thick gravel layer would placed over the geocomposite drainage layer.

The structural fill layer would consist of borrow soil or sandy tailings free of debris. This layer would be placed and compacted on top of the regraded tailings in areas of soft tailings and in areas requiring fill. The purpose of this layer is to achieve trafficability for heavy equipment to all areas of the tailings and provide a firm base free from protruding rocks and debris on which the overlying geosynthetic and soil layers would be placed. In areas of firm tailings, located primarily in the embankment area, the structural fill layer may not be required. The thickness of this layer would also depend on the regraded surface configuration.

An infiltration barrier consisting of a geosynthetic barrier layer would be placed over the structural fill layer. The geosynthetic barrier would have a permeability of 3x10 -9 cm/sec or less, based on manufacturer's data. A geocomposite drainage layer, consisting of drainage netting covered on both sides with a geotextile, would be installed over the geosynthetic barrier. This layer would provide a lateral drainage pathway for any infiltration that may accumulate on the geosynthetic barrier. The geotextile would allow water to infiltrate the drainage netting, but would prevent migration of fine soil particles that may plug openings in the netting (SMI/TerraMatrix, 1997).

An 18-inch-thick layer of plant growth media would be placed over the geocomposite drainage layer on the top of the impoundment. The plant growth media would consist of borrow soil screened to remove oversized rocks and amended, as required, with nutrients, manure, and/or organic matter to help establish and sustain vegetation. The amount and types of nutrients would be based on the analysis of the borrow material comprising this layer. The seed mixture for revegetation of the cover would contain both native and introduced grasses and forbs that would produce a self-sustaining plant community that would not require irrigation or nutrient supplements.

On the embankments of the impoundment, an 18-inch-thick layer of random fill would be placed over the geocomposite drainage layer. A 6-inch-thick gravel layer would be placed over the random fill layer to provide erosion protection.

The East Diversion Ditch would be constructed on the east side of the impoundment to convey runoff from the impoundment and to divert potential run-on flow away from the impoundment. This ditch would be built with a low-permeability lining to reduce infiltration (Figure 7). The discharge from the East Diversion Ditch, along with runoff from upstream Oregon Gulch, would flow to the South Diversion Ditch. This ditch would also be built with a low-permeability lining to minimize infiltration where the ditch is adjacent to the tailings impoundment. The South Diversion Ditch would follow its current alignment to a point approximately 100 feet northwest of the impoundment, where it would be directed through a drop channel to empty into the Oregon Gulch channel just upstream of the existing Sediment Control Pond. The existing South Diversion Ditch alignment downstream of the drop channel would be reclaimed by regrading the channel sideslopes to 3:1 or flatter and revegetating (SMI/TerraMatrix, 1997).

To reduce the potential for groundwater entering the tailings impoundment, an upgradient groundwater interceptor trench would be constructed in the Oregon Gulch channel upstream of the tailings impoundment (Figure 7). Collected groundwater would drain to the South Diversion Ditch. The Oregon Gulch channel upstream of the impoundment would also be lined from its confluence with the South Diversion Ditch to just upstream of the groundwater interceptor trench to minimize infiltration.

Temporary erosion and sediment control measures would be used around the perimeter of the site until the multi-layer cover is installed on the regraded embankment and impoundment surface; these measures may include silt fencing, straw bales, and possibly erosion control matting. A temporary sediment control dam, built as part of the Oregon Gulch Stream Sediment EE/CA will capture sediment from runoff from the northwest embankment. Following installation of the cover, the sediment control dam would not be needed and could be removed (SMI/TerraMatrix, 1997).

The Selected Remedy will include active managment of the seep currently discharging at the toe of the Oregon Gulch Tailing Impoundment during the interim period from implementation of the selected alternative until the seep does not negatively impact surface water quality. Active management of the seep discharge will be performed during non-freezing conditions and will include collection and either pumping or transport of the collected flow to the Yak Tunnel Treatment Plant or other suitable treatment options. Design of the Selected Remedy will include a drain system at the toe of the embankment to allow the seep discharge to flow unrestricted and to be collected in a controlled manner. After implementation of the Selected Remedy, seep flow rates are anticipated to decrease, lessening any potential water quality impacts during winter months.

9.2 CONTINGENCY MEASURES

Specific water quality goals for surface streams and heavy metals contamination have not been established at this time. EPA has agreed to establish specific surface and groundwater requirements at a later date when EPA, CDPHE, and the PRPs have reached agreement on the allowable heavy-metals contaminant loadings for each of the contributing source areas (operable units) for the entire California Gulch Superfund Site.

Existing data will be compared to water quality and sediment data collected after the Selected Remedy has been implemented. An evaluation of the degree of surface water-quality improvement will be made by EPA and CDPHE at that time. If the improvement in Oregon Gulch surface water quality is not considered sufficient then additional response actions may be performed.

The Selected Remedy will be designed to minimize active maintenance requirements. Post-closure maintenance of the impermeable cap and vegetative or rock armor cover will be used to ensure that the integrity and permance of the cap is maintained. Provisions for surveillance and repair will be established.

Because the Oregon Gulch Tailings Impoundment will remain on site, the Selected Remedy will require a five-year review under Section 121(c) of CERCLA and Section 300.430(f)(4)(ii) of the NCP. The five-year review includes a review of the groundwater and surface water monitoring data, inspection of the integrity of the cap, and an evaluation as to how well the Selected Remedy is achieving the RAOs and ARARs that it was designed to meet.

10.0 STATUTORY DETERMINATIONS

Under CERCLA Section 121, EPA must select a remedy that is protective of human health and the environment; that complies with ARARs; is cost effective; and utilizes permanent solutions, and alternative treatment technologies, or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that include treatment which permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as a principal element. The Selected Remedy does not satisfy the statutory preference for treatment as a principal element of the remedy. In narrowing the focus of the FFS, treatment of the Oregon Gulch Tailings Impoundment was determined to be impracticable. The following sections discuss how the Selected Remedy meets statutory requirements. A similar determination was made in selecting the Removal Action for the stream sediments as presented in the Action Memorandum (EPA, 1995).

10.1 PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The Selected Remedy protects human health and the envirorunent through the prevention of direct contact with contaminants at the site. The Selected Remedy uses engineered covers to effectively reduce direct contact, ingestion, and inhalation of all contaminants. The reduction in total loading of COCs to groundwater is estimated to be 99.8 percent resulting from implementation of the Selected Remedy. Loading of COCs to surface water runoff from the tailings was estimated to be reduced by 89 percent for lead, 96 percent for cadmium, 97 percent for TSS, and 99 percent or greater for arsenic, copper, zinc, and sulfate. Due to the significant reduction in infiltration resulting from the Selected Remedy, the Oregon Gulch Tailings Impoundment seep is predicted to stop flowing in less than approximately 7 years after implementation of this alternative, resulting in further reduction in surface water loading (SMI/TerraMatrix, 1997).

Potential risk to the terrestrial ecosystem due to ingestion or exposure to tailings would be eliminated by the Selected Remedy since the impoundment would be covered. Potential risk due to ingestion of ponded surface water on the tailings would be eliminated since the pond would not exist after regrading the tailings surface.

10.2 COMPLIANCE WITH ARARs

The Selected Remedy will comply with all ARARs identified in Appendix A to this ROD. No waiver of ARARs is expected to be necessary. Final performance standards will not include ARARs for Site-wide surface and ground waters or require a specified decrease in point or nonpoint source loadings of COCs to Site-wide surface and groundwaters (USCD, 1994).

10.3 COST EFFECTIVENESS

EPA has determined that the Selected Remedy is cost effective in mitigating the principal risks posed by contaminated tailings. Section 300.430(f)(ii)(D) of the NCP requires evaluation of cost effectiveness. Overall effectiveness is determined by the following three balancing criteria: long-term effectiveness and permanence; reduction of toxic1tv, mobility, and volume through treatment; and short-term effectiveness. Overall effectiveness is then compared to cost to ensure that the remedy is cost effective. The Selected Remedy meets the criteria and provides for overall effectiveness in proportion to its cost. The estimated cost for the Selected Remedy is S2.54 million. The cost estimate includes periodic inspection of the cover.

To the extent that the estimated cost of the Selected Remedy exceeds the cost for other alternatives, the difference in cost is reasonable when related to the greater overall effectiveness achieved by the Selected Remedy.

10.4 UTILIZATION OF PERMANENT SOLUTIONS AND ALTERNATIVE TREATMENT TECHNOLOGIES (OR RESOURCE RECOVERY TECHNOLOGIES) TO THE MAXIMUM EXTENT POSSIBLE

EPA has determined that the Selected Remedy represents the maximum extent to which permanent solutions can be utilized in a cost effective manner at the Oregon Gulch Tailings Impoundment.

Of those alternatives that are protective of human health and the environment and comply with ARARs, EPA has determined that the Selected Remedy for the Oregon Gulch Tailings Impoundment provides the best balance in terms of long-term effectiveness and permanence, treatment, implementability, cost, and state and community acceptance.

While the Selected Remedy for the tailings impoundment does not utilize the most permanent solution treatment or removal, the use of engineered covers provides a long-term effective and permanent barrier to contaminated waste materials, thus reducing risk to an equivalent extent. Because the tailings impoundment will remain on site with no treatment, the Selected Remedy will require a five-year review under Section 121(c) of CERCLA and Section 300.430(f)(4)(ii) of the NCP.

10.5 PREFERENCE FOR TREATMENT AS A PRINCIPAL ELEMENT

Various treatment options for impounded tailings were considered early in the FS process; however, due to the nature and size of the impounded tailings, these options were determined to be either technically impracticable and/or not cost-effective (EPA, 1993).

11.0 DOCUMENTATION OF SIGNIFICANT CHANGES

The Selected Remedy is the second response action to be taken at OU10 of the California Gulch Superfund Site. The first action implemented the Action Memorandum (EPA, 1995) for miscellaneous tailings and stream sediment in Oregon Gulch and was completed in October 1996. This removal action is consistent with the Selected Remedy for the Oregon Gulch Tailings Impoundment.

The Proposed Plan for the Oregon Gulch Tailings Impoundment was released for public comment on March 19, 1997. The Proposed Plan identified Alternative 5, Multi-Layer Rock and Soil cover with a Geosynthetic Barrier as the preferred alternative. No comments were received during the public comment period. Subsequently, the EPA determined that no significant changes to the remedy, as it was originally identified in the Proposed Plan, were necessary.

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FIGURES

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TABLES

TABLE 1

OREGON GULCH TAILINGS IMPOUNDMENT SOIL SAMPLE

LABORATORY RESULTS SUMMARY

CONSTITUENT	Sample Type	Number of Samples	Average (mg/Kg)	Median (mg/Kg)	Standard Deviation (mg/Kg)	Minimum (mg/Kg)	Maximum (mg/Kg)
Arsenic	STC	3	762.7	747	79.7	692	849
	FS	10	13.4	12.8	7.6	4.1	27.1
	T	24	486.1	439.5	245.6	191	1,430
Cadmium	STC	3	12.6	9.5	8.7	5.9	22.4
	FS	10	1.6	1.2	1.6	0.28	5.8
	T	24	55.3	47.4	36.9	25.3	196
Lead	STC	3	1,960.7	2,170	1,000.6	872	2,840
	FS	9	83.4	77	57.3	6.5	188
	T	24	4,587.9	3,475	2,814.7	1,010	13,800
Zinc	STC	3	1,740	1,280	1,302.4	730	3,210
	FS	10	284.8	185.5	271.9	45	898
	T	24	11,027.1	8,720	5,635.6	5,210	29,300

Source: Tailings R.I., (Woodward Clyde Consultants, 1994)

Notes: All units in milligrams per kilogram (mg/Kg)

STC = surface tailings composite samples

FS = foundation soils samples

T = subsurface tailings samples

TABLE 2
OREGON GULCH POND WATER QUALITY

Concentrations (mg/L)

Date	6/7/89	9/17/91	6/2/95	6/6/96	Average	Minimum	Maximum
Field pH (std. units)	2.24	1.91	2.60	3.3	2.51	1.91	3.3
Arsenic (diss.)	0.90	3.41 B	0.30	0.002 B	1.15	0.002	3.41
Arsenic (tot.)	0.88	5.30	0.29	0.007	1.62	0.007	5.30
Cadmium (diss.)	0.082	0.272	0.029	1.280	0.42	0.03	1.28
Cadmium (tot.)	0.085	0.225	0.022 B	1.210	1.54	0.02	1.21
Copper (diss.)	3.4	15.10	0.96	0.84	5.07	0.84	15.10
Copper (tot.)	3.7	12.2	0.89	0.96	17.75	0.89	12.20
Lead (diss.)	0.012	R	0.29	1.52	0.61	0.01	1.52
Lead (tot.)	0.021	46.8	0.32	1.63	12.12	0.02	46.80
Zinc (diss.)	16	39.0	3.95	181.0	59.99	3.95	181
Zinc (tot.)	15	36.3	4.20	172.0	56.88	4.20	172
Sulfate	4,300	19,820 J	880	1,760	4,190	880	9,820
TDS	4,600	8,560 J	1,150	2,710	4,255	1,150	8,560

Note: All values in milligrams per Liter except pH, U = Non-detect, B = Between method detection and instrument detection limit, J = Estimated through validation, R = Rejected through validation, Averages include non-detect values as the detection limit

SOURCE: SMI/TerraMatrix, 1996a

TABLE 3
OREGON GULCH SEEP WATER QUALITY

Concentrations (mg/L)

Date	6/7/89	10/25/89		9/17/91		6/2/94		10/5/94		6/1/95	6/27/95
Flow (gpm)	1.35	1.80		0.90		3.14		1.14		41.3	1.92
Field pH (std. units)	2.9	2.81		2.76		2.75		2.96		2.76	2.64
Arsenic (diss.)	0.036	0.05	U	0.120	B	0.104		0.048		0.28	0.2
Arsenic (tot.)	0.038	0.12		0.0412	BJ	0.093		0.072		0.29	0.2
Cadmium (diss.)	0.09	0.053		0.282		0.028		0.009		0.05	0.5
Cadmium (tot.)	0.08	0.07		0.278		0.31		1.05		0.04	0.6
Copper (diss.)	2	0.32		0.482	B	0.5	U	0.5	U	1.15	2.9
Copper (tot.)	2.3	0.62		1.19	BJ	1.75		0.5	U	1.05	2.8
Lead (diss.)	0.08	0.07		R		0.088		0.136		0.3	0.114
Lead (tot.)	0.09	0.68		0.193		0.175		0.29		0.37	0.171
Zinc (diss.)	930	730		1,130		780		1,030		15.4	672
Zinc (tot.)	940	790		1,090		780		990		14	718
Sulfate	35,000	30,000		27,700	J	27,000		35,274		1,230	34,400
TDS	51,000	49,000		12,900		46,100		58,096		1,420	47,300
TSS	86	560		862		NM		NM		16	224

Note: Constituent concentrations in milligrams per Liter (mg/L), flow in gallons per minute (gpm), U = Non-detect, J = Estimated concentration, R = Rejected through validation, NM = Not Measured, B = Between method detection limit and instrument detection limit

SOURCE: SMI/TerraMatrix, 1996a

TABLE 3 (continued)
OREGON GULCH SEEP WATER QUALITY

Loading (lbs/day)

Date	6/7/89	10/25/89	9/17/91	6/2/94	10/5/94	6/1/95	6/27/95
Flow (gpm)	1.35	1.80	0.90	3.14	1.14	41.3	1.92
Arsenic (diss.)	0.00058	0.00054 U	0.0013 B	0.0039	0.00066	0.14	0.0046
Arsenic (tot.)	0.00061	0.0026	0.00044 BJ	0.0035	0.00099	0.14	0.0046
Cadmium	0.0015	0.0011	0.0030	0.0011	0.00012	0.025	0.012
Cadmium (tot.)	0.0013	0.0015	0.0030	0.012	0.014	0.020	0.014
Copper (diss.)	0.032	0.0069	0.0052 B	0.019	0.0034 U	0.57	0.067
Copper (tot.)	0.037	0.013	0.013 BJ	0.033 U	0.0034 U	0.52	0.064
Lead (diss.)	0.0013	0.0015	R	0.0033	0.0019	0.15	0.0026
Lead (tot.)	0.0015	0.015	0.0021	0.0066	0.0040	0.18	0.0039
Zinc (diss.)	15	16	12	29	14	7.6	15
Zinc (tot.)	15	17	12	29	14	6.9	17
Sulfate	570	650	300 J	1,000	490	610	790
TDS	830	1,100	140	1,700	800	700	1,100
TSS	1.4	12	NM	NM	NM	7.9	5.2

Note: Constituent loadings in pounds per day (lbs/day), flow in gallons per minute (gpm), U = Non-detect concentration data, J = Estimated concentration data, R = Loading not calculated due to rejected data, NM = Not Measured, B = Between method detection limit and instrument detection limit. Average loading calculated using non-detect and estimated concentrations at values shown.

SOURCE: SMI/TerraMatrix, 1996a

TABLE 3 (continued)
OREGON GULCH SEEP WATER QUALITY

Concentrations (mg/L)

Date	7/26/95	8/31/95	9/27/95	10/26/95	5/17/96	6/6/96	Average	Maximum	Minimum
Flow (gpm)	0.85	1.92	1.17	3.08	4.49	1.34	4.95	41.3	0.85
Field pH (std.	2.82	2.97	2.95	2.95	2.7	3.21	2.86	3.21	2.64
Arsenic (diss.)	0.14	0.08	0.13	0.09	0.078	0.11	0.11	0.28	0.036
Arsenic (tot.)	0.128	0.155	0.116	0.23	0.08	5	0.50	5	0.038
Cadmium (diss.)	0.16	0.7	1 B	1.1 B	0.33	0.30	0.23	0.7	0.009
Cadmium (tot.)	0.6	0.54	0.59	1	1.3	1.9	0.64	1.90	0.04
Copper (diss.)	3.9	3.1	3	0.94	1.7	1.5	1.69	3.90	0.32
Copper (tot.)	2.9	3.6	3.6	0.95	1.54	1.56	1.87	3.60	0.50
Lead (diss.)	0.155	0.12	0.14	0.18	0.05	0.14	0.13	0.3	0.05
Lead (tot.)	0.13	1.23	0.32	0.86	0.11	0.14	0.37	1.23	0.09
Zinc (diss.)	740	835	938	884	488	825	769	1,130	15.4
Zinc (tot.)	742	818	918	1,100	479	799	783	1,100	14.0
Sulfate	31,400	31,500	32,900	34,400	18,400	29,700	28,377	35,274	1,230
TDS	36,500	49,800	52,300	61,700	28,290	49,500	41,838	61,700	1,420
TSS	198	136	216	646	86	202	294	862	16

Note: Constituent concentrations in milligrams per Liter (mg/L), Flow in gallons per minuter (gpm), U = Non-detect, J = Estimated concentration data, R = Rejected through validation, NM = Not Measured, B = Between method detection limit and instrument detection limit

SOURCE: Terra-Matrix, 1996a

TABLE 3 (concluded)
OREGON GULCH SEEP WATER QUALITY

Loading (lb/day)

Date	7/26/95	8/31/95	9/27/95	10/26/95	5/17/96	6/6/96	Average	Maximum	Minimum
Flow (gpm)	0.85	1.92	1.17	3.08	4.49	1.35	4.95	41.3	0.85
Arsenic (diss.)	0.0014	0.0018	0.0018	0.0033	0.0042	0.002	0.013	0.14	0.00054
Arsenic (tot.)	0.0013	0.0036	0.0016 B	0.0085 B	0.0043	0.081	0.022	0.14	0.00044
Cadmium	0.0016	0.016	0.014	0.041	0.018	0.005	0.011	0.041	0.00012
Cadmium (tot.)	0.0061	0.012	0.0083	0.037	0.070	0.031	0.018	0.07	0.0013
Copper (diss.)	0.040	0.071	0.042	0.035	0.092	0.024	0.077	0.57	0.0034
Copper (tot.)	0.030	0.083	0.051	0.035	0.081	0.025	0.076	0.52	0.0034
Lead (diss.)	0.0016	0.0028	0.0020	0.0067	0.003	0.002	0.015	0.15	0.0013
Lead (tot.)	0.0013	0.028	0.0045	0.032	0.006	0.002	0.022	0.18	0.0013
Zinc (diss)	7.6	19	13	33	26	13	17	33	7.6
Zinc (tot.)	7.6	19	13	41	26	13	18	41	6.9
Sulfate	320	730	460	1,300	990	480	670	1,300	300
TDS	370	1,100	730	2,300	1,500	800	1000	2,300	140
TSS	2.0	3.1	3.0	24	4.6	3.3	6.7	24	1.4

Note: Constituent loadings in pounds per day (lbs/day), flow in gallons per minute(gpm), U = Non-detect concentration data, J = Estimated concentration data, R = Loading not calculated due to rejected data, NM = Not Measured, B = Between method detection limit and instrument detection limit. Average loading calculated using non-detect and estimated concentrations at values shown.

SOURCE: SMI/TerraMatrix, 1996a

TABLE4

OREGON GULCH SOUTH DIVERSION DITCH WATER QUALITY

	Concentration (mg/L)	Loading (lb/day)	Concentration (mg/L)	Loading (lb/day)	Concentration (mg/L)	Loading (lb/day)
Date	6/l/95	6/l/95	5/8/96	5/8/96	5/17/96	5/17/96
Flow (gpm)	565.5	565.5	1391.4	1391.4	40.4	40.4
Field pH (std. units)	4.08	NA	4.11	NA	3.24	NA
Arsenic (diss.)	0.001 U	0.003U	0.001U	0.017	0.001	0.0005
Arsenic (tot.)	0.026	0.177	0.047	0.787	0.002	0.001
Cadmium (diss.)	0.008	0.054	0.006	0.100	0.016	0.008
Cadmium (tot.)	0.008	0.054	0.007	0.117	0.014	0.007
Copper (diss.)	0.014	0.095	0.019	0.318	0.054	0.026
Copper (tot.)	0.046	0.312	0.043	0.719	0.049	0.024
Lead (diss.)	0.007	0.048	0.014	0.23	0.023	0.011
Lead (tot.)	0.38	2.58	0.35	5.85	0.037	0.018
Zinc (diss.)	0.94	6.38	0.83	13.8	1.83	0.89
Zinc (tot.)	1.38	9.37	0.98	16.41	1.92	0.93
Sulfate	40 U	135.8U	30	502.2	110	53.5
TDS	60	407	100	1,674	160	77.8
TSS	1,750	11,885	326	5,457.3	6.0	2.92

Note: U - Non-detect at concentration value shown, loading labeled with U are calculated using non-detect concentration.
NA - Not Applicable.

SOURCE: SMI/TerraMatrix, 1996a

TABLE 5
OREGON GULCH SURFACE WATER QUALITY (OG-1)

Concentrations (mg/L)

Date	5/2/91	6/12/91	7/24/91	5/17/94	5/26/94	5/4/95	5/16/95
Flow (gpm)	216	0.45	0.27	4.5	0.45	1.35	259
Field pH (std. units)	3.33	2.32	2.55	2.45	2.25	2.20	2.51
Arsenic (diss.)	0.0158 BJ	R	0.268	0.006	0.008	0.015	0.089
Arsenic (tot.)	0.245	0.0336 BJ	0.601	0.005	0.008	0.049	0.47
Cadmium (diss.)	0.11 J	0.555	0.664	0.15	0.0135	0.43	0.35
Cadmium (tot.)	0.0895 J	0.557 J	0.549	0.15	0.215	0.41	0.4
Copper (diss.)	0.893 J	8.42	2.27	2.2	3.3	3.88	2.2
Copper (tot.)	10.2 J	7.8	2.34	2.15	2.9	3.7	2.22
Lead (diss.)	0.0473 R	R	0.001 U	0.01	0.005	0.012	0.03
Lead (tot.)	25.5 J	R	3.6	0.006	0.018	0.31	2.7
Zinc (diss.)	114 J	644	557	205	297	712	252
Zinc (tot.)	1,110 J	634 J	559 J	192	285	717	255
Sulfate	3,300	7,480	R	5,840	9300	24,300	10,000
TDS	6,010	29,600	9,430	10,100	15,400	37,900	13,800
TSS	522 J	80	490 J	NM	NM	330	1,260

Note: All constituent concentrations in milligrams per Liter (mg/L), U = Non-detect, J = Estimated concentration, R = Rejected through validation, NM = Not measured B = Between method dection limit and instrument detection limit

SOURCE: SMI/TerraMatrix, 1996a

TABLE 5 (continued)
OREGON GULCH SURFACE WATER QUALITY (OG-1)

Loading (lb/day)

Date	5/2/91		6/12/91		7/24/91		5/17/94	5/26/94	5/4/95	5/16/95
Flow (gpm)	216		0.45		0.27		4.49	0.45	1.35	259
Arsenic (diss.)	0.041	BJ	R		0.00087		0.00032	4.3E-05	0.00024	0.28
Arsenic (tot.)	0.64		1.8E-04	BJ	0.0019		0.00027	4.3E-05	0.00079	1.5
Cadmium (diss.)	0.29	J	0.0030		0.0022		0.0081	7.3E-05	0.0070	1.1
Cadmium (tot.)	0.23	J	0.0030	J	0.0018		0.0081	0.0012	0.0066	1.3
Copper (diss.)	2.3	J	0.045		0.0073		0.12	0.018	0.063	6.9
Copper (lot.)	26	J	0.042		0.0076		0.12	0.016	0.060	6.9
Lead (diss.)	0.12		R		1.6E-06	U	0.00054	2.7E-05	0.00019	0.093
Lead (tot.)	66	J	R		0.012		0.00032	0.00010	0.0050	8.4
Zinc (diss.)	300	J	3.5		1.8		11	1.6	12	790
Zinc (tot.)	2,900	J	3.4	J	1.8	J	10	1.5	12	790
Sulfate	8,600		40		R		320	50.4	390	31,000
TDS	16,000		160		30		540	83	610	43,000
TSS	1,300	J	0.43		1.6	J	NM	NM	5.3	3,900

Note: All constituent loadings in pounds per day (lbs/day), flow in gallons per minute (gpm), U = Non-detect concentration data, J = Estimated concentration data, R = Loading not calculated due to rejected data, NM = Not Measured, B = Between method detection limit and instrument detection limit. Average loading calculated using non-detect and estimated concentrations at values shown.

SOURCE: SMI/TerraMatrix, 1996a

TABLE 5 (continued)
OREGON CULCH SURFACE WATER QUALITY (OG-1)

Concentrations (mg/L)

Date	5/23/95	6/1/95	6/7/95	6/14/95	6/27/95	7/26/95	5/7/96
Flow (gpm)	956	646	350	5.97	7.6	0.63	1504
Field pH (std. units)	3.02	2.9	3.4	2.65	2.49	2.49	3.39
Arsenic (diss.)	0.062	0.012	0.002	0.012	0.009	0.06	0.003
Arsenic (tot.)	0.23	0.11	0.058	0.012	0.01 U	0.044	0.23
Cadmium (diss.)	0.09	0.05	0.023	0.04	0.3	0.18	0.06
Cadmium (tot.)	0.11	0.04	0.029	0.19	0.2	0.5	0.129
Copper (diss.)	0.62	0.35	0.25	1.8	2.5	4.5	0.3
Copper (tot.)	0.75	0.28	0.239	2.1	2.7	3.4	0.43
Lead (diss.)	0.03	0.023	0.04	0.024	0.03	0.06	0.038
Lead (tot.)	1.28	0.48	0.6	0.067	0.032	0.039	1.75
Zinc (diss.)	50.9	26	14.8	136	196	596	31.7
Zinc (tot.)	50.2	25.2	14.7	140	211	590	30.5
Sulfate	1,900	990	510	4,800	8,200	24,500	1130
TDS	3,030	1,310	740	7,070	12,300	36,800	1760
TSS	524 J	476	962	26	46	132	884

Note: All constituent concentrations in milligrams per Liter (mg/L), U = Non-detect, J = Estimated concentration, R = Rejected through validation NM = Not measured B = Between method dection limit and instrument detection limit U = Non-detect through validation at value shown, J = Estimated through validation, R = Rejected through validation, NM = Not measured

SOURCE: SMI/TerraMatrix, 1996a

TABLE 5 (continued)
OREGON GULCH SURFACE WATER QUALITY (OG-1)

Loading (lb/day)

Date	5/23/95	6/l/95	6/7/95	6/14/95	6/27/95	7/26/95	5/7/96
Flow (gpm)	956	646	350	5.97	7.58	0.63	1504
Arsenic (diss.)	0.71	0.093	0.0084	8.6E-04	8.2E-04	4.5E-04	0.054
Arsenic (tot.)	2.6	0.85	0.24	8.6E-04	4.6E-04	U 3.3 E-04	4.2
Cadmium (diss.)	1.0	0.39	0.097	0.0029	0.027	0.0014	1.1
Cadmium (tot.)	1.3	0.31	0.12	0.014	0.018	0.0038	2.3
Copper (diss)	7.1	2.7	1.1	0.13	0.23	0.034	5.4
Copper (tot.)	8.6	2.2	1.0	0.15	0.25	0.026	7.8
Lead (diss.)	0.34	0.18	0.17	0.0017	0.0027	4.5E-04	0.68
Lead (tot.)	15	3.7	2.5	0.0048	0.0029	2.9E-04	130
Zinc (diss.)	580	200	62	9.7	18	4.5	570
Zinc (tot.)	580	200	62	10	19	4.5	550
Sulfate	22,000	7,700	2,100	340	750	190	20,000
TDS	35,000	10,000	3,100	510	1,100	280	32,000
TSS	6,000	J 3,700	4,000	1.9	4.2	1.0	16,000

Note: All constituent loadings in pounds per day (lbs/day), flow in gallons per minute (gpm), U = Non-detect concentration data, J = Estimated concentration data, R = Loading not calculated due to rejected data, NM = Not Measured, B = Between method detection limit and instrument detection limit. Average loading calculated using non-detect and estimated concentrations at values shown.

SOURCE: SMI/TerraMatrix, 1996a

TABLE 5 (Continued)
OREGON GULCH SURFACE WATER QUALITY (OG-1)

Concentrations (mg/L)

Date	5/8/96		5/17/96	6/6/96		Average	Maximum	Minimum
Flow (gpm)	1526		63	3.1		326	1526	0.27
Field pH	3.49		3.38	3.09		2.82	3.49	2.20
Arsenic (diss.)	0.0010	B	0.007	0.005	U	0.04	0.27	0.001
Arsenic (tot.)	0.05		0.004	0.005	B	0.13	0.60	0.004
Cadmium (diss.)	0.032		0.09	0.15		0.19	0.66	0.014
Cadmium (tot.)	0.067		0.09	0.26		0.23	0.56	0.029
Copper (diss.)	0.15		0.7	1.7		2.1	8.42	0.15
Copper (tot.)	0.19		0.64	1.7		2.6	10.20	0.19
Lead (diss.)	0.046		0.026	0.02		0.028	0.060	0.001
Lead (tot.)	0.57		0.027	0.03		2.3	25.50	0.006
Zinc (diss.)	15.9		68.4	133		238	712	14.8
Zinc (tot.)	16.1		66	133		296	1,110	14.7
Sulfate	530		2400	5190		6738	24,500	510
TDS	880		3630	8710		11,675	37,900	740
TSS	830		10	54		442	1,260	10

Note: All constituent concentrations in milligrams per Liter (mg/L), U = Non-detect through validation at value shown, J = Estimated through validation, R = Rejected through validation, NM = Not measured

SOURCE: SMI/TerraMatrix, 1996a

TABLE 5 (concluded)
OREGON GULCH SURFACE WATER QUALITY (OG-1)

Loading (lb/day)

Date	5/8/96		5/17/96	6/6/96		Average	Maximum	Minimum
Flow (gpm)	1256		63	3.1		310	1504	0.27
Arsenic (diss.)	0.02	B	0.005	0.0002	U	0.08	0.71	0.00004
Arsenic (tot.)	0.92		0.003	0.0002		0.64	4.2	0.00004
Cadmium (diss.)	0.59		0.068	0.006		0.28	1.1	0.00007
Cadmium (tot.)	1.2		0.068	0.01		0.40	2.3	0.0012
Copper (diss.)	2.8		0.53	0.064		1.7	7.1	0.007
Copper (tot.)	3.5		0.48	0.064		3.4	26	0.008
Lead (diss.)	0.85		0.02	0.001		0.15	0.85	0.000002
Lead (tot.)	10		0.02	0.001		15	130	0.0001
Zinc (diss.)	2,900		52	5.0		350	2,900	1.6
Zinc (tot.)	300		50	5.0		320	2,900	1.5
Sulfate	9,700		1,800	200		7,000	31,000	40
TDS	16,000		2,700	330		9,500	43,000	30
TSS	15,000		7.6	2.0		3300	16,000	0.43

Note: All constituent loadings in pounds per day (lbs/day), flow in gallons per minute (gpm), U = Non-detect concentration data, J = Estimated concentration data, R = Loading not calculated due to rejected data, NM = Not Measured, B = Between method detection limit and instrument detection limit. Average loading calculated using non-detect and estimated concentrations at values shown.

SOURCE: SMI/TerraMatrix, 1996a

TABLE 6
INTERMEDIATE ALLUVIAL AQUIFER WATER QUYALITY (mg/L)

Location	OG1TMW1	OG1TMW1	OG1TMW1	OG1TMW9	OG1TMW9	OG1TMW1	OG1TMW9			
Date	10/31/91	6/1/94	10/12/94	10/11/94	1/26/95	6/6/96	6/6/96			
Source	WCC	SMI	SMI	SMI	SMI	SMI	SMI	Average	Minimum	Maximum
Field pH	7.72	7.75	8.33	7.80	7.75	8.1	7.8	7.89	7.72	8.33
Arsenic (diss.)	0.01 U	0.001	0.001	0.002	0.001	0.002 B	0.002 B	0.00	0.001	0.002
Cadmium (diss.)	0.005 U	0.0001 U	0.0001 U	0.0002	0.0001	0.0005 U	0.0005 U	0.0011	0.0001 U	0.0002
Copper (diss.)	0.025 U	0.01 U	0.01 U	0.01 U	0.01 U	0.001 U	0.001 U	0.013 U	0.01 U	0.001 U
Lead (diss.)	0.003 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.0014 U	0.001 U	0.001 U
Zinc (diss.)	0.02 U	0.01 U	0.01 U	0.01 U	0.01 U	0.01 U	0.1	0.027 U	0.001 U	0.1
Sulfate	1749 U	10 U	6	315	414	10	490	208	6	490
TDS	190	129	140	620	684	130	820	387.6	129	820

Note: All constituent concentrations in milligrams/Liter (mg/L) unless otherwise noted.
Sources: 1991 sample concentration data: Hydrogeologic R.I. (Golder, 1996b)
1994 through June 1996 data: Water Sampling Program Data Transmittals SMI/TMI (1994, 1995,1996)
U = Non-detect, J = Estimated through validation, R = Rejected through validation
B = Between method detection limit (MDL) and instrument detection limit (IDL), NM = Not Measured

TABLE 7
TAILING IMPOUNDMENT PORE WATER QUALITY

Location	OG1TMW4	OG1TMW5	OG1TMW5	OG1TMW5	OG1TMW6A	OG1TMW6A			
Date	10/30/91	10/30/91	6/2/94	10/6/94	10/31/91	6/5/96			
Source	WCC	WCC	SMI	SMI	SMI	SMI	Average	Minimum	Maximum
Field pH	4.14	5.22	5.35	4.9	5.10	4.24	4.82	4.14	5.35
Arsenic (diss.)	1 U	1 U	0.021	0.043	1.0 UJ	0.01 U	0.03	0.021	0.043
Cadmium (diss.)	0.5 U	0.5 U	0.082	0.0165	0.5 U	0.032	0.27	0.0165	0.082
Copper (diss.)	2.5 U	2.5 U	5 U	0.01 U	2.5 U	0.01 U	2.5 U	0.01 U	5 U
Lead (diss.)	0.432	0.339	1.22	1.98	4.66	0.95	1.59	0.339	4.66
Zinc (diss.)	528	214	272	178	1,150	580	487	178	1150
Sulfate	30,300	14,400	16,300	9,220	29,900	23,900	20,670	9,220	30,300
TDS	60,400	24,000	23,200	14,400	23,400	37,300	30,450	60,400	14,400

Note: All constituent concentrations in milligrams/Liter (mg/L) except pH.
Sources: 1991 sample concentration data: Hydrogeologic R.I. (Golder. 1996b)
1994 through June 1996 data: Water Sampling Program Data Transmittals SMI/TMI (1994, 1995, 1996)
U = Non-detect, J = Estimated through validation, R = Rejected through validation, B = Between method detection limit (MDL) and instrument detection limit (IDL), NM = Not Measured

TABLE 8
PERCHED AQUIFER WATER QUALITY - OG1TMW3

Date	10/31/91	10/21/91	6/2/94	10/6/94	1/25/95	6/1/95	9/26/95	6/6/96			
Source	WCC	SMI	SMI	SMI	SMI	SMI	SMI	SMI	Average	Minimum	Maximum
Field pH	2.15	2.25	2.58	1.90	2.27	2.52	2.59	2.81	2.38	1.90	2.81
Arsenic (diss.)	1 UJ	0.02	0.033	0.02	0.04	0.01	0.25	0.02	0.17	0.008	0.25
Cadmium (diss.)	0.568	0.37	0.26	0.052	0.56	0.6	0.6	0.5	0.5	0.26	0.568
Copper (diss.)	8.08	4.94	4.4	5.15	6.4	5.5	4.4	4.2	5.6	4.4	8.08
Lead (diss.)	0.3 U	0.005	0.05 U	0.001 U	0.001 U	0.001	0.01	0.005 U	0.005	0.001 U	0.01
Zinc (diss.)	861	760	812	735	880	961	585	746	792	585	961
Sulfate	29,400	28,647	24,600	25,519	29,700	33,400 J	22,500	26,600	27,545	22,500	33,400
TDS	45,300	39,710	44,600	39,000	46,300	49,800	34,700	43,700	42,888	34,700	49,800

Note: All constituent concentrations in milligrams/Liter (mg/L) except pH.
Sources: 1991 sample concentration data: Hydrogeologic R.I. (Golder, 1996b)
1994 through June 1996 data: Water Sampling Program Data Transmittals SMI/TMI (1994, 1995, 1996)
U = Non-detect, J = Estimated concentration, R = Rejected through validation, B = Between method detection limit (MDL) and instrument detection limit (IDL), NM = Not Measured

TABLE 8 (concluded)
PERCHED AQUIFER WATER QUALITY - OG1TMW8

Date	10/30/91	6/2/94	10/11/94	1/25/95	6/1/95	9/26/95			
Source	WCC	SMI	SMI	SMI	SMI	SMI	Average	Minimum	Maximum
Field pH	4.06	4.29	4.20	4.06	4.24	4.11	4.16	4.06	4.29
Arsenic (diss.)	1 UJ	0.006	0.007	0.005	0.002	0.02	0.01	0.002	0.016
Cadmium (diss.)	0.5 U	0.1	0.117	0.12	0.13	0.13	0.119	0.1	0.13
Copper (diss.)	2.5 U	5 U	1 U	0.4 U	0.004	0.1	0.05	0.004	0.1
Lead (diss.)	0.3 U	0.005	0.003	0.018	0.009	0.012	0.009	0.005	0.018
Zinc (diss.)	672	745	610	672	812	525	673	525	812
Sulfate	30,000	27,000	35,200	32,700	39,600	30,000 J	32,400	27,000	39,600
TDS	50,600 J	50,700	46,100	47,300	61,200	45,800	50,300	45,800	61,200

Note: All constituent concentrations in milligrams/Liter (mg/L) except pH.
Sources: 1991 sample concentration data: Hydrogeologic R.I. (Golder, 1996b)
1994 through June 1996 data: Water Sampling Program Data Transmittals SMI/TMI (1994, 1995, 1996)
U = Non-detect, J = Estimated concentration, R = Rejected through validation, B = Between method detection limit (MDL) and instrument detection limit (IDL), NM = Not Measured

TABLE 9

LOADING TO CALIFORNIA GULCH FROM OREGON GULCH SHALLOW GROUND WATER

Location	OG1TMW3	OG1TMW3	CG-4 Average	CG-4	OGITMW3
	Average	Average Loading	Concentrations	Average Loading	Loading as %
Concentrations	(lbs/day)	(I s/day)	of CG-4		
	Concentrations	(lbs/day)		(lbs/day)	of CG-4
Flow	2.8*		1,632		0.31%
Field pH (std. units)	2.38		4.97		
Arsenic (diss.)	0.17	0.02	0.002	0.04	50%
Cadmium (diss.)	0.50	0.01	0.11	2.14	0.5%
Copper (diss.)	5.6	0.19	0.31	6.05	3.1%
Lead (diss.)	0.005	0.0002	0.31	6.05	0.003%
Zinc (diss.)	792	26.9	26.5	517	5.2%
Sulfate	27,545	933	750	14,645	6.4%

Note: All constituent concentrations in milligrams/Liter (mg/L) except pH, Flow in gallons per minute (gpm). All loading in pounds per day (lbs/day).

Sources: 1991 sample concentration and flow measurement data: Hydrogeologic R.I. (Golder, 1996b)

1994 through June 1996 data: Water Sampling Program Data Transmittals SMI/TMI (1994, 1995, 1996)

* Flow estimated in Appendix C, Section C.4 of the FFS (SMI/TerraMatrix 1996a).

TABLE 10
SEDIMENT SAMPLE ANALYSIS RESULTS (WWL SAMPLING EVENT, JUNE 1989)

Analytes	Units	OG-1 (Just above confluence with California Gulch)	OG-2 (Seep at toe of impoundment)	OG-3 (S. diversion ditch downstream of impoundment)
Pyritic Sulfur	%	4.3	1.2	12
Silver (total)	mg/kg	13	22	23
Arsenic (total)	mg/kg	200	79	220
Cadmium (total)	mg/kg	5.8	19	10
Chromium (total)	mg/kg	4.5	5.8	2.1
Copper (total)	mg/kg	380	550	540
Iron (total)	%	8.7	8.7	17
Manganese (total)	mg/kg	1,500	3,200	600
Lead (total)	mg/kg	750	3,900	1,600
Zinc (total)	mg/kg	1,800	6,900	1,500

SOURCE: SMI/TerraMatrix, 1996a

TABLE 11
STREAM SEDIMENT SAMPLE ANALYSIS RESULTS

	California Gulch CG-3	Starr Ditch SD-1	Oregon Gulch OG-1	California Gulch CG-4
Arsenic (mg/kg)				
Jun-89	190	190	200	20
May-91	290	147	152	146
Jul-91	214	2.8	2.3	61.5
Sep-91	152			56.7
Mar-92	199	48.05		116
Oct-93	104			169
May-94	150			70
Cadmium (mg/kg)				
Jun-89	28	28	5.8	16
May-91	26.9	438	1.5	17.3
Jul-91	18	19.8	4.6	8.5
Sep-91	13.2			9.9
Mar-92	24.8	7.6		11.3
Oct-93	10			12
May-94	7			7
Copper (mg/kg)				
Jun-89	720	450	380	610
Jul-91	1,070	296	109	593
Sep-91	1,260			319
Mar-92	895	91.9		319
Oct-93	406			494
May-94	484			296
Iron (mg/kg)				
May-91	93,500	44,100	53,900	75,400
Jul-91	82,700	46,500	47,000	31,000
Sep-91	80,000			30,000
Mar-92	84,700	17,500		47,300

Note: 1989 sample sites were re-designated with name of nearest current site.

SOURCE: SMI/TerraMatrix, 1996a

TABLE 11 (concluded)
STREAM SEDIMENT SAMPLE ANALYSIS RESULTS

	California Gulch CG-3	Starr Ditch SD-1	Oregon Gulch OG-1	California Gulch CG-4
Oct-93	59,600			71,800
May-94	55,600			46,300
Lead (mg/kg)				
Jun-89	2,000	4,200	750	3,200
May-91				
Jul-91	2,130	2,380	633	1,220
Sep-91	2,180			1,170
Mar-92	2,620	578		2,150
Oct-93	1,320			3,170
May-94	1,680			1,830
Sulfate (mg/kg)				
May-91	816	324	3,570	1,690
Jul-91	1,060	1,960	6,920	450
Sep-91	270			410
Mar-92	362	49		262
Zinc (mg/kg)				
Jun-89	6,000	6,400	1,800	4400
May-91			1,820	
Jul-91	3,710	6,410	683	2,530
Sep-91	5,210			3,040
Mar-92	6,100	1,680		4,190
Oct-93	3,480			5,060
May-94	3,130			2,750

Note: 1989 sample sites were re-designated with name of nearest current site.

SOURCE: SMI/TerraMatrix, 1996a

TABLE 12
HAZARD INDICES FOR TERRESTRIAL RECEPTORS FROM EXPOSURE TO
CONTAMINANTS IN TAILINGS, SURFACE WATER, AND SEDIMENTS
PRELIMINARY ECOLOGICAL RISK ASSESSMENT FOR OREGON GULCH (OU10)

Receptor	HI Average Intake	HI Reasonable Maximum Intake
Passerine	2160.23	3606.21
Raptor	1991.01	3296.88
Small herbivore	97.26	139.91
Large herbivore	35.2	54.47
Small omnivore	111.68	155.59
Large omnivore	32.78	45.66

TABLE 13
HAZARD QUOTIENTS FOR AQUATIC LIFE EXPOSED
TO SURFACE WATER FROM OREGON GULCH

Analyte	Acute AWQC Average	Acute AWQC RME	Chronic AWQC Average	Chronic AWQC RME
Aluminum	NA	NA	NA	NA
Antimony	NA	NA	NA	NA
Arsenic	0.41	0.78	0.79	1.48
Barium	NA	NA	NA	NA
Beryllium	NA	NA	NA	NA
Cadmium	133.63	200.30	473.80	710.16
Chromium	0.09	0.17	0.71	1.40
Copper	252.35	550.33	378.53	825.49
Iron	NA	NA	NA	NA
Lead	0.01	0.31	0.01	0.31
Mercury	0.05	0.05	9.80	9.80
Manganese	NA	NA	NA	NA
Nickel	0.45	0.77	3.94	6.74
Selenium	0.33	0.50	1.33	2.00
Silver	0.13	0.19	NA	NA
Thallium	NA	NA	NA	NA
Zinc	3715.69	6313.73	4053.48	6887.70

Note: Cd, Cu, Pb, Ni, Zn are hardness dependent; a hardness of 100 mg/l was used to calculate the AWQC. HQs based on EPA Acute and Chronic Criteria.

SOURCE: Preliminary Ecological Risk Assessment for Oregon Gulch (OU10), Weston, 1995a

TABLE 14
HAZARD QUOTIENT FOR AQUATIC LIFE
EXPOSED TO SEDIMENT FROM OREGON GULCH

Analyte	Average	RME
Aluminum	NA	NA
Antimony	NA	NA
Arsenic	13.90	27.39
Barium	4.50	6.25
Beryllium	NA	NA
Cadmium	1.04	1.58
Chromium	0.41	0.56
Copper	14.29	14.29
Iron	6.77	7.24
Lead	9.59	9.59
Mercury	0.60	0.60
Manganese	0.81	0.87
Nickel	0.29	0.39
Selenium	NA	NA
Silver	NA	NA
Thallium	NA	NA
Zinc	NA	NA

NA = Not Available

SOURCE: Preliminary Ecological Risk Assessment for Oregon Gulch (OU10), Weston, 1995a

TABLE 15

HAZARD INDICES FOR SURFACE MEDIA BY RECEPTOR FOR OU10

OU	Blue Grouse	Mtn. Bluebird	American Kestrel	Red-tail Hawk	Bald Eagle	Least Chipmunk	Mule Deer	Red Fox
OU10	10	252	2	0	0	25	0	0

SOURCE: Weston, Inc. and Terra Technologies, 1997.

TABLE 16
COMPARISON OF ALTERNATIVES FOR THE OREGON GULCH TAILING IMPOUNDMENT - NCP CRITERIA

	Alternative 1 No Action	Alternative 2 Simple Vegetated Cover	Alternative 3 Clay Layer Vegetated Cover	Alternative 4 Soil Cover with Geosynthetic Barrier	Alternative 5 Multi-Layer Soil Cover with Geosynthetic Barrier
Overall Protection of Human Health and the Environment (This criterion includes whether the remedial action objectives [RAOS] would be met)	Does not meet RAOS. Allows continued contamination of ground and surface water. Continued erosion of tailing from the existing embankment slopes.	Good overall protection. Meets RAOS: -Controls airborne releases -Controls erosion -Controls releases to surface water -Reduces releases to groundwater	Good overall protection. Meets RAOS: -Controls airborne releases -Controls erosion -Controls releases to surface water -Further reduces releases to groundwater	Very good overall protection. Meets RAOS: -Controls airborne releases -Controls erosion -Controls releases to surface water -Provides high level of protection to groundwater	Excellent overall protection Meets RAOS: -Controls airborne releases -Controls erosion -Controls releases to surface water -Provides highest level of groundwater protection
Compliance with ARARs	Not an issue.	Complies with all ARARs.	Complies with all ARARs.	Complies with all ARARs.	Complies with all ARARs.
Long-Term Effectiveness and Permanence	No long-term effectiveness.	Good long-term effectiveness and permanence.	Good long-term effectiveness and permanence.	Very good long-term effectiveness and permanence.	Excellent long-term effectiveness and permanence.
Reduction of Toxicity, Mobility, or Volume through Treatment	Treatment not applicable.	Mobility reduced, treatment not applicable.	Mobility reduced, treatment not applicable.	Mobility reduced, treatment not applicable.	Mobility reduced, treatment not applicable.
Short-Term Effectiveness	No disturbance to the community. Not effective in reducing short-term risk to the environment.	Some short-term risk to the community due to dust emissions, increased traffic, and to workers regrading the tailing surface.	Some short-term risk to the community due to dust emissions, increased traffic, and to workers regrading the tailing surface.	Some short-term risk to the community due to dust emissions, increased traffic, and to workers regrading the tailing surface.	Some short-term risk to the community due to dust emissions, increased traffic, and to workers regrading the tailing surface.
Implementability	Not an issue.	Relatively easy to implement.	Relatively easy to implement.	Geosynthetic installation may require specialized equipment and manpower.	Geosynthetic installation may require specialized equipment and manpower.
Cost	$0	$1.83 Million	$1.98 Million	$2.27 Million	$2.54 Million
Agency Acceptance	Not Likely.	Possibly.	Possibly.	Likely.	Most Likely.
Community Acceptance	Not Likely.	Possibly.	Possibly.	Likely.	Most Likely.

SOURCE: SMI/TerraMatrix, 1996a

<IMG SRC 97145K>
<IMG SRC 97145L>
<IMG SRC 97145M>
<IMG SRC 97145N>

TABLE 21
COMPARISON 0F ALTERNATIVES FOR OREGON GULCH TAILING IMPOUNDMENT - WAMP CRITERIA

	Alternative 1 No Action	Alternative 2 Simple Vegetated Cover	Alternative 3 Clay Layer Vegetated Cover	Alternative 4 Soil Cover with Geosynthetic Barrier	Alternative 5 Multi-Layer Rock and Soil Cover with Geosynthetic Barrier
Surface Erosion Stability	No erosional stability measures would be taken. Embankments do not meet WAMP criteria.	All surfaces would be stabilized with vegetation to meet WAMP criteria.	All surfaces would be stabilized with vegetation to meet WAMP criteria.	All surfaces would be stabilized with vegetation to meet WAMP criteria.	Embankment stabilized with rock and top surfaces stabilized with vegetation to meet WAMP criteria.
Slope Stability	The existing embankment slopes do not meet WAMP criteria.	The embankment slopes would be regraded to 2.75:1 or flatter to meet WAMP criteria.	The embankment slopes would be regraded to 2.75:1 or flatter to meet WAMP criteria.	The embankment slopes would be regraded to 2.75:1 or flatter to meet WAMP criteria.	The embankment slopes would be regraded to 2.75:1 or flatter to meet WAMP criteria.
Flow Capacity and Stability	Existing diversion ditches have the capacity to carry the 100-yr, 24-hr flood, but do not meet WAMP stability criteria.	Diversion ditches and channels would be sized and stabilized for the 100-yr, 24-hr flood to meet WAMP criteria.	Diversion ditches and channels would be sized and stabilized for the 100-yr, 24-hr flood to meet WAMP criteria.	Diversion ditches and channels would be sized and stabilized for the 100-yr, 24-hr flood to meet WAMP criteria.	Diversion ditches and channels would he sized and stabilized for the 100-yr, 24-hr flood to meet WAMP criteria.
Surface Water (SW) and Groundwater (GW) Contaminant Loading Reduction	No reduction in loading; seep flow would continue.	84.4% GW loading reduction; 89% to 100% SW loading reduction; seep may continue to flow.	93.3% GW loading reduction; 89% to 100% SW loading reduction.	96.6% GW loading reduction; 89% to 100% SW loading reduction.	99.8% GW loading reduction; 89% to 100% SW loading reduction.
Terrestrial Ecosystem Exposure	Continued risk to terrestrial ecosystem exists from ingestion of contaminated surface water and tailing.	The risk to terrestrial ecosystem is minimized.	The risk to terrestrial ecosystem is minimized.	The risk to terrestrial ecosystem is minimized.	The risk to terrestrial ecosystem is minimized.
Non-Residential Soils	Not applicable. Non-residential soils do not exist on the tailing impoundment.	Not applicable. Non-residential soils do not exist on the tailing impoundment.	Not applicable, Non-residential soils do not exist on the tailing impoundment.	Not applicable. Non-residential soils do not exist on file tailing impoundment.	Not applicable. Non-residential soils do not exist on the tailing impoundment.

SOURCE: SMI/TerraMatrix, 1996a

APPENDIX A

ARARS

SUMMARY OF FEDERAL AND STATE LOCATION-SPECIFIC ARARS FOR OU10

Standard, Requirement Criteria, or Limitation	Citation	Applicable	Relevant and Appropriate	Description
FEDERAL				
Endangered Species Act	16 USC º 1531 et seq 50 CFR ºº 200 and 402	No	No	Provides protection for threatened and endangered species and their habitats. However, site-specific studies did not document the presence of threatened or endangered species. If threatened or endangered species are encountered during remedial activities in OU10, then requirements of Act would be applicable.
Fish and Wildlife Coordination Act	16 USC º 661 et seq. 40 CFR 16 º 6.302	No	No	Requires coordination with federal and state agencies to provide protection of fish and wildlife in water resource development program, regulates actions that impound, divert, control, or modify any body of water. However, proposed remedial action activities in OU10 will not affect fish or wildlife. If It appears that remedial activities may impact wildlife resources, EPA will coordinate with both the U.S. Fish and Wildlife Service and the Colorado Department of Natural Resources.
Wilderness Act	16 USC 1311, 16 USC 668 50 CFR 53, 50 CFR 27	No	No	Limits activities within area designated as wilderness areas or National Wildlife Refuge Systems.
Executive Order No. 11988 Floodplain Management	40 CFR º 6.302 & Appendix A	Yes	---	Pertains to floodplain management and construction and impoundments in such areas.
Executive Order No. 11990 Protection of Wetlands	40 CFR º 6.302(a) and Appendix A	Yes	---	Minimizes adverse impacts on areas designated as wetlands.
Section 404, Clean Water Act (CWA)	33 USC 1251 et seq. 33 CFR Part 330	Yes	---	Regulates discharge of dredged or fill materials into waters of the United States. Substantive requirements of portions of Nationwide Permit No. 38 (General and Specific Conditions) are applicable to OU10 remedial activities conducted within waters of the United States.

SUMMARY OF FEDERAL AND STATE LOCATION-SPECIFIC ARARS FOR OU10 (Continued)

Standard, Requirement Criteria, or Limitation	Citation	Applicable	Relevant and Appropriate	Description
The Historic and Archaeological Data Preservation Act of 1974	16 USC 469 40 CFR º 6.301 (c)	Yes	---	Establishes procedures to preserve historical and archeological data that might be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity program. A cultural resource survey was completed in OU10 to identify historic properties which may be affected by remedial activity.
National Historic Preservation Act (NHPA)	16 USC º 470 et seq. 40 CFR º 6.301(b) 36 CFR Part 63, Part 65, Part 800	Yes	---	Expands historic preservation program; requires preservation of resources included in or eligible for listing on the National Register for Historic Places.
Executive Order 11593 Protection and Enhancement of the Cultural Environment	16 USC º 470	Yes	---	Directs federal agencies to institute procedures to ensure programs contribute to the preservation and enhancement of non-federally owned historic resources. Consultation with the Advisory Council on Historic Preservation is required if remedial activities should threaten cultural resources.
Historic Sites Act of 1935	16 USC º 461-467	No	No	Preserves for public use historic sites, buildings, and objects of natural significance.
The Archeological Resources Protection Act of 1979	16 USC º 470aa-47011	No	Yes	Requires a permit for any excavation or removal of archaeological resources from public lands or Indian lands. Maybe relevant and appropriate if archeological resources are encountered during remedial action activity.
Resource Conservation and Recovery Act (RCRA). Subtitle D	40 CFR Part 257, Subpart A, º 257.3-1 Floodplains, paragraph (a)	Yes	---	Provides general classification criteria for solid waste disposal facilities pertaining to floodplains.
		STATE OF COLORAD0		
Nongame, Endangered or Threatened Species Act	CRS ºº 33-2-101 to 108	No	No	Standards for regulation of nongame wildlife and threatened and endangered species. Site-specific studies did not document the presence of threatened or endangered species. If threatened or endangered species are encountered during remedial activities in OU10, then requirements of Act will be applicable.

SUMMARY OF FEDERAL AND STATE LOCATION-SPECIFIC ARARS FOR OU10 (Continued)

Standard, Requirement Criteria, or Limitation	Citation	Applicable	Relevant and Appropriate	Description
Colorado Register of Historic Places	CRS °° 24-80.1-101 to 108	No	No	Authorizes the State Historical Society to nominate properties for inclusion on the State Register of Historic Places Applicable only if remedial action activities impact an area listed on the Register.
Colorado Historical, Prehistorical, and Archaeological Resources Act	CRS °° 24-80-401 to 410 1301 to 1305	No	Yes	Concerns historical, prehistorical, and archaeological resources; applies only to areas owned by the State or its political subdivisions. May be relevant and appropriate if remedial action impacts an archaeological site.
Colorado Species of Special Concern and Species of Undetermined Status	Colorado Division of Wildlife Administrative Directive E-1, 1985, modified	No	No	Protects species listed on the Colorado Division of Wildlife generated list. Urges coordination with the Division of Wildlife if wildlife species are to be impacted. No evidence of species of special concern have been identified at this site.
Colorado Natural Areas	Colorado Revised Statutes, Title 33 Article 33, Section 104	No	No	Maintains a list of plant species of "special concern." Although not protected by State statue, coordination with Division of Parks and Outdoor Recreation is recommended if activities will impact listed species.
Colorado Solid Waste Disposal Sites and Facilities Act,	6 CCR 1007-2 6 CCR 1007-2, Part I	No	No	Establishes regulations for solid waste management facilities, including location standards. Proposed remedial action in OU10 will not establish a solid waste management facility.

SUMMARY OF FEDERAL AND STATE ACTION-SPECIFIC ARARS FOR OU10

Standard, Requirement Criteria, or Limitation	Citation	Applicable	Relevant and Appropriate	Description
FEDERAL				
Solid Waste Disposal Act as amended by the Resource Conservation and Recovery Act of 1976 (RCRA)	40 CFR Part 257, Subpart A: º 257.3-1 Floodplains, paragraph (a); º 257.3-7 Air, paragraph (b)	Yes	---	Selected portions of Part 257 pertaining to floodplains and air are applicable. These provisions establish criteria for classification of solid waste disposal facilities and practices.
Hazardous Materials Transportation Act	49 USC º 1801-1813 49 CFR 107, 17,-177	No	No	Regulates transportation of hazardous materials. Proposed remedial action in OU10 will be conducted on private property and will not entail off-site transportation of hazardous materials.
STATE OF COLORADO				
Colorado Solid Waste Disposal Sites and Facilities Act	6 CCR 1007-2	No	No	Establishes standards for licensing, locating, constructing and operating solid waste facilities. Proposed remedial action in OU10 will not involve establishment of a solid waste disposal facility.
Colorado Water Quality Control Act, Storm Water Discharge Regulations	5 CCR 1002-2	Yes	---	Establishes requirements for storm water discharges (except portions relating to Site-wide Surface and Groundwater). Substantive requirements for storm water discharges associated with construction activities are applicable.
Colorado Mined Land Reclamation Act	CRS 34-32-101 to 125 Rule 3 of Mineral Rules and Regulations	No	Yes	Regulates all aspects of land use for mining, including the location of mining operations and related reclamation activities and other environmental and socio-economic impacts. Substantive requirements of selected portions of Rule 3 regarding Reclamation Measures, Water - General Requirements (except portions relating to Side-wide Surface and Ground Water). Wildlife, and Revegetation are potentially relevant and appropriate.
Colorado Air Pollution Prevention and Control Act	5 CCR 1001-3; Sections III.D.1.b,c,d Sections III.D.2.b,c,e,f,g. Regulation 1	Yes	---	Regulation No. 1 provisions concerning fugitive emissions for construction activities, storage and stockpiling activities, haul roads, haul trucks, and tailing ponds are applicable (5 CCR 1001-3; Sections III.D.2.b,c,e,f,g.). Construction activities in OU10 will be conducted in accordance with a fugitive emissions control plan.

SUMMARY OF FEDERAL AND STATE ACTION-SPECIFIC ARARS FOR OU10 (Continued)

Standard, Requirement Criteria, or Limitation	Citation	Applicable	Relevant and Appropriate	Description
Colorado Noise Abatement Act	CRS °° 25-12-101 to 108	Yes	---	Establishes maximum permissible noise levels for particular time periods and land use related to construction projects.
Regulations on the Collection of Aquatic Life	2 CCR 406-8, Ch. 13, Article III, Sec. 1316	No	No	Requirements governing the collection of wildlife for scientific purposes. Remedial action activities within OU10 will not include biological monitoring.
Colorado Hazardous Waste Regulations	6 CCR 1007-3, Part 264: Section 264.301, (g), (h), (i), and (j); Section 264.310, (a)(1) through (a)(4); Section 264.310, (b)(1) and (b)(5)	No	Yes	These specific provisions of the hazardous waste regulations may be relevant and appropriate for conducting remedial actions in OU10. Specific provisions of Section 264.301 concern run-on control, run-off control, management of run-on and run-off control system, and wind dispersal. Specific provisions of Section 264.310 concern placement of a cover to minimize infiltration, minimize maintenance, promote drainage and minimize erosion, and accommodate settling.
Colorado Air Pollution Prevention and Control Act	5 CCR 1001-4 Regulation 2 Odors	Yes	---	Applicable only if remedial action activities cause objectionable odors. Remedial action in OU10 is not expected to product odors.
Colorado Air Pollution Prevention and Control Act	5 CCR 1001-5 Regulation 3 APENs	Yes	---	Substantive provisions of APENs will be met.

SUMMARY OF FEDERAL AND STATE CHEMICAL-SPECIFIC ARARS FOR OU10

Standard, Requirement Criteria, or Limitation	Citation	Applicable	Relevant and Appropriate	Description
FEDERAL				
Clean Air Act, National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50	No	No	National ambient air quality standards (NAAQS) are implemented through the New Source Review Program and State Implementation Plans (SIPs). The federal New Source Review program address only major sources. Emissions associated with proposed remedial action in OU10 will be limited to fugitive dust emissions associated with earth moving activities during construction. These activities will not constitute a major source. Therefore, attainment and maintenance of NAAQS pursuant to the New Source Review Program are not ARARs. See Colorado Air Pollution Prevention and Control Act concerning applicability of requirements implemented through the SIP.
RCRA Land Disposal Restrictions (LDRs)	40 CFR Part 268	No	No	RCRA LDRs are not applicable because the materials in issue have been identified as extraction or beneficiation wastes that are specifically exempted from the definition of a hazardous waste. Not relevant and appropriate, see Superfund LDR Guide #7.

Standard, Requirement Criteria, or Limitation	Citation	Applicable	Relevant and Appropriate	Description
STATE OF COLORADO				
Colorado Air Pollution Prevention and Control Act	5 CCR 1001-14 5 CCR 1001-10 Part C(I) & (II) Regulation 8	Yes	---	Pursuant to the Colorado Air Pollution Prevention and Control Act applicants for construction permits are required to evaluate whether the proposed source will exceed NAAQS Applicants are also required to evaluate whether the proposed activities would cause the Colorado ambient standard for TSP to be exceeded. Construction activities associated with the proposed remedial action in OU10 will be limited to generation of fugitive dust emissions. Colorado regulates fugitive emissions through Regulation No. 1. Compliance with applicable provisions of the Colorado air quality requirements will be achieved by adhering to a fugitive emissions control plan prepared in accordance with Regulation No. 1. Regulation 8 sets emission limits for lead and hydrogen sulfide. Applicable are required to evaluate whether the proposed activities would result in the Regulation 8 lead standard being exceeded. The proposed remedial action in OU10 is not projected to exceed the emission levels for lead or hydrogen sulfide, although some lead emissions may occur. Compliance with Regulation 8 will be achieved by adhering to a fugitive emissions control plan prepared in accordance with Regulation No. 1.